APPENDIX D. DATA COLLECTION

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Appendix D. DATA COLLECTION

This chapter describes: the selection of agencies and data sets for calibrating the new methodology, the HOV facilities operated by each agency, the availability of before/after studies, and the methods used to reduce each before/after study for use in the methodology development database.

D.1 DATA COLLECTION PROCEDURE

This section describes the procedures used to obtain data sets for developing and validating a methodology for predicting the demand for HOV lanes and their impacts on traffic congestion and air quality.

The data collection effort proceeded in four steps. First, the types of data necessary for developing and validating the methodology were determined based on the likely input, output, and desired sensitivities of the new methodology. Second, nine agencies, representative of HOV environments throughout the United States were selected for data collection. Third, "before and after" data was collected on the HOV facilities currently operated by each agency. Fourth, a single, coherent data set was then assembled based upon each "before and after" study.

Gaps in data were filled in where appropriate data could be obtained from other sources or by applying logical assumptions based upon the supplemental data sources. All data was converted into a consistent level of disaggregation and format for use in validation and methodology development.

Step One: Determination of Data Needs

The purpose of this project is to provide a "quick response" methodology for predicting and evaluating the impacts of HOV lanes on person demand, vehicle demand, auto occupancy, congestion, delay, and air quality. The methodology should be sensitive to parameters known to influence HOV demand (such as travel time and delay) and to user specified control parameters such as eligibility rules for HOV's. The methodology should be applicable to both freeway and arterial HOV lanes.

Consequently the ideal data set should provide "before and after" data on person demand, vehicle demand, auto occupancy, congestion, and delay'. The data sets should span different HOV lane facility types and facilities with different occupancy rules. The data sets should include both arterial and freeway HOV facilities.

A key requirement of the data sets is that the data sets provide data for both before and after the implementation of an HOV lane or a change in eligibility rules. This is crucial in order to be able to determine the impact of the installation of an HOV lane.

No new raw data collection was feasible as part of this study, because of the time schedule for the study. Valid after data must be gathered at least 6 months to one year after the opening of an HOV lane to allow time to measure the cumulative effects of an HOV lane on travel demand.

Pre-existing studies of existing HOV lanes had to be relied on in order to obtain the necessary "before and after" data for each facility.

Several agencies have extensive monitoring programs that measure speeds, volumes, and occupancies for existing HOV lanes. However, most of these monitoring programs were not implemented until "after" the HOV lane was already in place. Thus much of this extensive data was not of direct use to this study.

The needed "before and after" data falls into two broad groups - operations data and survey data (see Table D-l). Operations data typically includes traffic volume counts and vehicle occupancy counts for the HOV lane and the adjacent freeway lanes. The ideal data sets had vehicle volume counts by occupancy (1,2,3,4+) and by vehicle

1 Air pollutant emissions can be predicted using standard emission models. It is beyond the scope of this study to obtain field data for validating the standard emission models.

type (car, motorcycle, truck, bus, van) for each lane type (HOV, and mixed flow); however, many studies only provided an overall average occupancy for the HOV lanes and the mixed flow lanes. Traveler survey data was useful for determining the influence of HOV lanes on the various aspects of total demand: mode shift, route shift, and time shift.

Table D-l. Desired Characteristics of Before/After Data Sets

Data Type	Before	After
Facility Description (Required)		
Location, Facility Type, Length, Number of Lanes (HOV and Mixed Flow)	√	√
Date HOV Lane Opened, Hours of Operation, Occupancy Requirements		√
Operations Data (Required)		
Vehicle Counts by occupancy type (1,2, 3,4+), vehicle type (auto, trucks, buses, vans, motorcycles), and lane type (HOV, mixed flow).	√	√
Travel Times (Average and Maximum for Peak Hour and Peak Period)(HOV lane and mixed flow lanes)	√	√
Traveler Surveys (Optional)		
Proportion of "after" SOV's and HOV's that shifted from other modes, other routes, other time oeriods		√

Before data should be collected preferably within one month of project opening, but can be as much as 18 months prior to opening. After data should be collected preferably no sooner than 6 months after project opening, but can be as much as 18 months later.

Step Two: Selection of Agencies

Nine agencies were selected for data collection based upon their geographic distribution, the HOV facilities they operate, and the availability of before/after data.

The specific criteria were:

1. Representative geographic distribution of the U.S. Since the methodology and software is being developed for use by agencies across the U.S., the nine agencies should cover several geographic areas. Although the majority of the existing HOV facilities are located in California, agencies were selected to represent several regions including the South, West Coast, East Coast, and Midwest.
2. Representative of several different types of HOV facilities. For maximum efficiency in data collection, the agencies selected should operate several different types of HOV facilities. Since concurrent flow facilities are the most popular facility type, they should be well-represented among the nine agencies. Barrier-separated and contra-flow HOV projects should be included. Agencies that operate different types of facilities were preferred. A special effort was made to include agencies that operate arterial HOV facilities.
3. Availability of before-and-after data. The last criteria, and the most crucial, is the availability of before-and-after data, preferably in a published report. A published report ensures consistency in data collection methodology for the before and after data collection efforts. Raw data taken from agency files is more difficult to control for consistency of methodology. In addition, routine data collection rarely includes occupancy or travel time measurements, except for the few agencies with extensive HOV monitoring programs. This specialized data has been historically collected only if an agency is conducting a specific "before and after" study. Monitoring programs in Houston, Seattle, and the San Francisco Bay Area are among the few programs to routinely collect the specialized data needed to evaluate the effectiveness of HOV lanes.

4. Cooperative Ability. All agencies contacted were sympathetic to the objectives of this project, however; some agencies did not have the personnel resources available to devote to internal searches of available HOV data.

The following nine agencies were selected for data collection based upon the above criteria:

1. Caltrans, District 4, San Francisco, California;
2. Caltrans, Districts 7 & 11, Los Angeles/San Diego, California;
3. Minnesota DOT, Minneapolis, Minnesota;
4. New Jersey DOT, Trenton, New Jersey;
5. Metropolitan Transit Authority of Harris County, Houston, Texas;
6. Virginia DOT, Richmond, Virginia;
7. Washington DOT, Seattle, Washington;
8. Santa Clara County, San Jose, California; and
9. Snohomish County, Seattle, Washington,

The nine agencies operate a combined total of 55 freeway and arterial HOV projects with a total of 586 lane-miles (943 lane-km). The selected agencies together operate 49% of the 1188 freeway HOV lane-miles (1,912 lane-km) in the United States and Canada. Many of the selected agencies collect and publish data on HOV lane usage annually, semi-annually, or quarterly. Most have conducted "before and after" studies for some of their HOV facilities.

Each of the agencies was contacted to determine the availability of before and after data for their HOV facilities. Table D-2 summarizes the types of data available in published "before-and-after" reports.

Caltrans District 11 (San Diego) and Houston Metro have the most comprehensive before and after data for their HOV facilities. Caltrans District 4 (San Francisco) and Santa Clara County collected mainly peak period data in their "before and after" studies. Minnesota DOT and Washington DOT gathered mainly peak hour data in their "before and after" studies.

It should be noted that Caltrans, Minnesota, and Washington currently have monitoring programs in place to gather much more extensive data than is cited here. These monitoring programs however often did not start early enough to provide "before" data for many HOV facilities. We have consequently sought published before and after studies by each agency that provide the "before" data for each facility.

Step Three: Collection Of Before/After Data

Each agency was requested to forward a copy of every available published "before and after" study for HOV facilities under their control. Some agencies no longer had available copies of "before/after" studies for projects which were opened over 20 years ago. In those cases, the University of California, Institute of Transportation Studies library and Systan Inc. files were searched for information on the older projects.

Minnesota DOT, the Texas Transportation Institute, and the California State University, San Diego (Caltrans District 11) had available to most extensive series of "before and after" studies for their HOV facility projects.

New Jersey DOT's "before and after" study of their I-80 facility is still in progress and could not yet be released at the date of publication of this report.

Agencies also provide copies of their monitoring program reports. The Texas Transportation Institute, Caltrans District 4, Washington Metro COG, and Washington State DOT provided extensive monitoring data.

The history of each HOV facility was then reviewed to determine which "changes" in facility operation or characteristics would be useful "actions" for inclusion in the methodology development database. Each action consists of a change in the length or operating rules (e.g. 2+ versus 3+ Carpools allowed).

It was particularly valuable when several "actions" could be identified on a single facility, because then the effects of different actions on the identical facility could be tested without interference caused by differences in driver types in different geographic areas. The Katy Transitway in Houston, and the I-5 freeway in Seattle were two particularly rich sources of multiple "actions" occurring on the same facility.

Several, otherwise excellent "before/after" studies were not eliminated because of potential distortions that could occur when multiple changes or "actions" occur within a short time period. A portion of the I-394 data set was not included in the database because the later portions of the HOV project occurred at the same time as freeway construction was proceeding. Some of the earlier studies of the Shirley Highway in Washington D.C. have not been included because of potential confusion of the effects of gasoline shortages in 1973 and 1979 with the impacts of the HOV facility.

It was not generally possible to "create" complete before/after data sets for a particular facility by combining different studies. Different studies gathered data at different geographic locations or for different time periods. It was particularly important that the travel time studies be conducted at about the same time as the volume counts. For this reason, travel time studies from one study were not combined with volume counts from another study to create a new data set.

A total of 27 "before/after" data sets out of a total 55 projects operated by the nine agencies have been identified and included in the methodology development database. The following chapter discusses the rationale for including or excluding each data set in the database.

Step 4: Data Reduction

The various "before/after" data sets identified in the previous step were reduced and consolidated into a single consistent database. This step involved converting percentages into volumes, translating travel time data into travel time differences, and tilling in gaps in the reported data based upon information available from related sources.

For example, vehicle occupancies were reported for the overall (HOV plus mixed flow) facility but not specifically for the HOV or mixed flow lanes in a few cases. This information plus information on violation rates, average vehicle occupancy by lane, and total lane volumes was then used to assign vehicles by occupancy type to each lane type.

In other cases, travel times were reported for a section of the freeway that was longer than the section in which the HOV lane was located. These times were converted to travel times for the shorter section of freeway with the HOV lane by assuming that all of the observed travel time difference between the HOV lane floating car run and the mixed flow lane floating car run was due to the HOV lane.

In some cases, only mean or only maximum travel time savings were reported and these had to be converted to the other measurement using an estimated ratio of mean to maximum travel times based on data collected on the Houston and San Francisco HOV facilities.

Table D-2. Available Before/After Data

	Caltrans Dist. 4 (SF)	Caltrans Dist. 7/12	Caltrans Dist. 11	Minnesota DOT	New Jersey DOT	Texas Metro	Virginia DOT	Washington State DOT	Santa Clara Co.	Washington Kings Co.
0. Individual Contacted Telephone #	Mr. David Seriani (510) 286-4653	Mr. Ron Klusza (213) 897-0788	Mr. Arian Abrishami (619) 688-3206	Mr. Mark Die-rling (612) 341-7372	Ms. Barbara Fischer (609) 530-2468	Mr. Don Garri-son (713) 802-5171	Mr. Kanathur Srikanth (703) 934-0608	Mr. Eldon Jacobson (206) 685-3187	Mr. Ananth Pra-sad (408) 494-1342	Mr. Mike Wong (206) 296-6506
Before and After Studies/Reports	US 101 Marin I-280 S.Clara S.Clara 237	I-10 LA I-210 LA LA 91 Orange 55	I-15 (San Diego)	I-394 (Minneapolis)	I-80[2] (Morris Co.)	I-10 Katy US 290 NW I-45 North	I-395[3] (North Virginia)	I-90 I-5	San Tomas	128th/Airport
Peak Hour Data	[4]									
Vehicle Counts	√	√	√	√		√		√		√
Person Counts	√	√	√	√		√		√		√
Veh. by Occupancy	√	√	√	√		√		√		
Max. SOV Times	√	√	√			[5]		√		
Ave. SOV Times	√	√	√	√				√		√
Peak Period Data		[6]								
Vehicle Counts	√	√	√			√	√		√	
Person Counts	√	√	√			√	√		√	
Veh. by Occupancy	√	√	√			√				
Max. SOV Times	√	√	√			√			√	
Ave. SOV Times	√	√	√			√			√	
Traveler Surveys	1990, 1995		√			√				

2 Study in progress. After study had not been released by September 6, 1995.

3 Excellent historical data available for HOV lanes only. Mixed flow lane data is limited. No travel time studies performed concurrent with volume counts,

4 Peak hour data available only for one of the U.S. 101 HOV projects. No peak period data available for this same project.

5 Only more recent travel time data (circa 199 1) is currently readily obtainable. Travel time for older projects estimated based upon 1991 data.

6 Peak period data available only for I-10 (El Monte and Santa Monica) projects. No peak hour data available for these two projects.

D.2 MINNESOTA DEPARTMENT OF TRANSPORTATION

The Minnesota Department of Transportation operates HOV facilities on two corridors in the Minneapolis-St. Paul area. These HOV lanes requires a vehicle occupancy of 2 or more persons. Table D-3 summarizes the facility characteristics for the HOV facilities in the Twin Cities region. The I-394 facility is described in greater detail in the Project Profiles.

Minnesota DOT operates the 8 HOV ramp meter bypasses on I-394 as well as 34 other HOV ramp meter bypasses in the Twin Cities Metro Area. These are part of a system of 367 ramp meters which are all operated by the Minnesota DOT's Traffic Management Center (TMC).[7]

The Minnesota Department of Transportation has collected data on I-394 since one year prior to the opening of the interim HOV lane in 1984 and continues to collect data periodically. Daily and monthly data has been collected since the interim facility opened in 1985.

A comprehensive traveler survey was conducted in October 1986. A telephone survey of persons regularly using I-394 during the peak periods for work was conducted of 403 households from January 2 1 to February 5, 1993. The survey included traveler profiles, trip profiles, and commuter attitudes.

A before/after report is not available for the I-35W HOV facility.

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Minnesota Department of Transportation
Tel: (612) 341-7372

D.2.1 I-394 Traveler Surveys

Several traveler surveys (surveys of HOV drivers and non-HOV drivers) were conducted throughout the I-394 evaluation study. A comprehensive traveler survey was conducted in October 1986. The survey indicated that the growth in carpooling came from both modal and spatial shifts. The survey results showed that during the AM peak hour 25% of the carpoolers were previously carpoolers on Highway 12, 26% were carpoolers on other routes, 38% previously drove alone, and 11% were former bus riders. Route shifts (from various modes) accounted for almost 40% of all the new carpoolers on the facility (see Figure D-l).

In 1989, another survey of regular lane users, HOV lane users, and bus riders was conducted on April 5 and 12. A total of 6,173 surveys were distributed with a 1,802 surveys returned. The results of the April 1989 diversion survey showed that during the AM Peak hour 34% of the carpoolers were previous carpoolers on Highway 12, 11% were carpoolers on other routes, 39% previously drove alone, and 15% were former bus riders. The percentage of carpoolers from other routes fell from 26% in 1986 to 11% in 1989, representing the effects of the construction in 1989.

A telephone survey of persons regularly using I-394 during the peak periods for work was conducted of 403 households was conducted from January 21 to February 5, 1993. The survey included user profiles, trip profiles, and commuter attitudes. The survey results identify the current mode of travel along I-394 and the potential to change the modal distribution through direct questions. The survey does not ask about previous mode, but asks about the duration of the present mode, which gives some idea if the mode choice was related to the opening of the HOV lane.

7 Mn/DOT Freeway Operations Program Status Report, January 1995.

Table D-3. Minnesota Freeway HOV Lane Characteristics

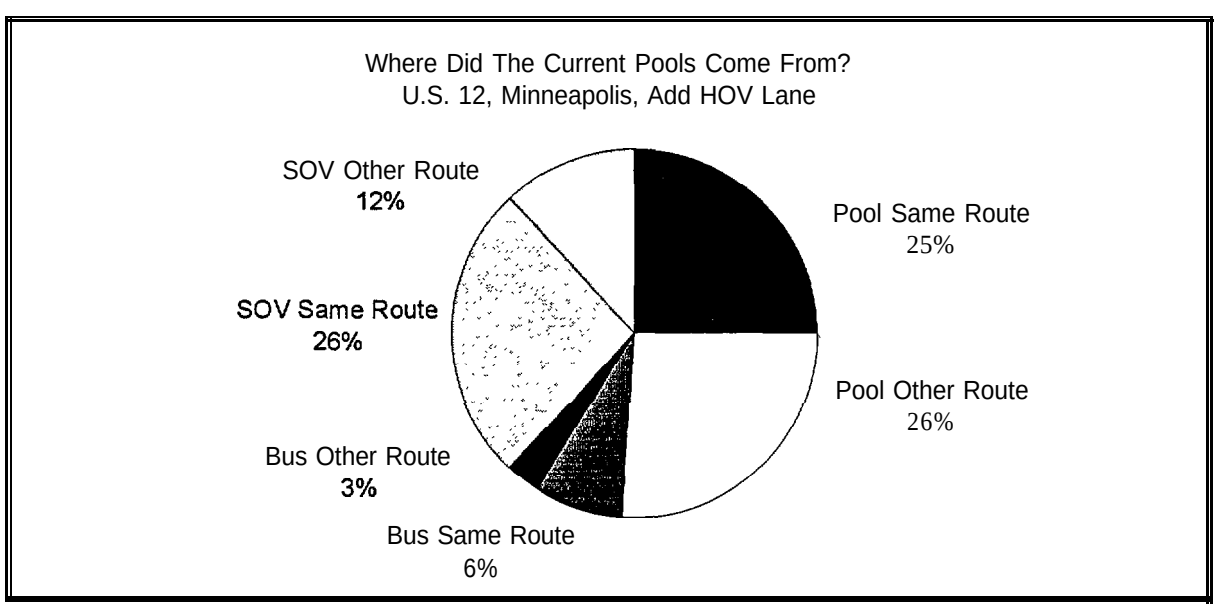
Characteristics	Minnesota DOT		
Corridor	I-394 Minneapolis		I-35W
Begin and End /Ramp Location	T.H. 101 to Hwy 100	Hwy 100 to I-94	T.H. 13 Bumsville to I-494 Bloomington
# of Directional HOV lanes	2	2	1
Length (mi.)	8	3	6
Date Operational	90	92	94
HOV Eligibility	2+	2+	2+
Hours of HOV Operation (weekdays only)	6-9 AM EB 2-6 PM WB	6-10:30am EB 2pm-midnight WB	6-9 AM, 3-6 PM both directions
Type of facility'	striped concurrent each dir.	barrier separated re-versible lane	concurrent in each dir.
Ramp Metering	8 locations		none
Park-and-ride facilities	8 lots		?
Other support facilities/programs (rideshare program)	3 downtown garages, parking incentives, transit timed transfer stations		

Sources:

Allan Pint, Charleen Zimmer Joseph Kern, Leonard Palek. "Evaluation of the Minnesota I-394 HOV Transportation System", TRB, 74th annual meeting, January 1995.

Glen Carlson, MnDOT, 1995.

Figure D-l Where l-394 Carpoolers Came From



8 All HOV lanes are on the left side unless otherwise noted.

D.2.2 I-394 HOV Facility - Minneapolis, Minnesota

The I-394 HOV lanes and freeway is located west of downtown Minneapolis. The HOV lanes are part of a system that includes transit facilities, park-and-ride lots, parking garages, and skyways. Table D-3 summarizes the characteristics for the I-394 HOV system.

I-394 was constructed on the alignment of US 12, an existing arterial, and extends 1 l-miles west from downtown Minneapolis. East of Highway 100, three miles of barrier separated reversible HOV lanes are located in the freewaymedian. Access and egress are limited to the ends of the 3-mile section at Highway 100 and I-94. West of Highway 100, eight miles of concurrent flow HOV lanes with unlimited access are in operation.

Project History

An interim HOV lane was opened to traffic on November 19, 1985. The interim project provided additional person-carrying capacity during the construction of I-394. The interim facility was a single reversible-flow lane in the median of US 12, a signalized arterial. A short section of left hand side concurrent flow lanes were used to carry the HOV facility under a railroad underpass.

The reversible median lane was replaced with temporary concurrent flow lanes during freeway construction. Construction lasted from April 1987 to October 1992.

The reversible HOV lane between downtown and T.H 100 was partially completed in November 1990. The entire HOV and freeway project was opened in October 1992.

Selection of Before/After Data Sets

Three distinct HOV facility changes or "actions" on the I-394 HOV facility can be identified as candidates for inclusion in the methodology development database:

1. Construction of Reversible Median Lane,
2. Construction of Interim HOV lanes during freeway construction,
3. Construction of Final HOV lanes T.H. 101 to I-94.

The latter two actions however occurred during the construction of the freeway and thus it is impossible to separate out the effects of the HOV lanes from the effects of the freeway construction. Consequently these last two actions have not been included in the methodology development data base.

Data Collection

The Minnesota Department of Transportation collected data one year prior to the opening of the interim HOV lane in 1984 and continues to collect data periodically. Daily and monthly HOV lane data has been collected since the interim facility opened in 1985. The 1984 baseline data was for Trunk Highway 12, which was a signalized arterial, and for parallel roadways. The data consist of vehicle volumes, Carpools in the corridor, bus ridership, auto occupancy, and travel times.

Minnesota DOT is in the final phase of a four-phase evaluation study of the I-394 facility. For Phase I, data was collected in 1986 during the first year of operation. Phase II covered the construction period from 1987 to 1992. The Phase II Report published in 1990 focused on the effectiveness of the interim lane. Phase III, the start-up period from 1993 to 1994, was recently completed. The final phase of the study covers stable operations over the next five years.

The Phase I, 1984 baseline data was collected for Trunk Highway 12, which was a signalized arterial, and for parallel roadways.

The Phase II evaluation consisted of continuous counts, biennial counts, and one-time counts. Volumes, transit boardings, and downtown garage counts were made on a continuous basis. Every six months data was collected on vehicle occupancy, travel time, transit peak loading, park-and-ride lot utilization, and traffic counts for the parallel

facility, T.H. 55. One time data collection efforts included a telephone survey conducted in 1993, a license plate survey of park-and-ride users in May 1993, and vehicle occupancy and queue length counts at all I-394 on-ramps in August 1993.

The data collected for the Phase III evaluation consisted of continuous counts, biennial counts, and one-time counts. Volumes, transit boardings, and downtown garage counts were made on a continuous basis. Every six months data was collected on vehicle occupancy, travel time, transit peak loading, park-and-ride lot utilization, and traffic counts for the parallel facility, T.H. 55. One time data collection efforts included a telephone survey conducted in 1993, a license plate survey of park-and-ride users in May 1993, and vehicle occupancy and queue length counts at all I-394 on-ramps in August 1993.

Data is available for the AM peak hour, AM peak period, the PM peak hour, and PM peak period, in the peak and off-peak direction. The April 1984 data represents "before" conditions on the signalized arterial. May 1986 data represents operations of the interim facility. The vehicle counts and occupancy data is for all vehicles, including passenger automobiles, buses, and trucks. The data represent the peak load point of the facility. Once the facility was complete and the barrier-separated HOV lanes east of T.H. 100 were opened, data was collected on I-394 at Penn Avenue. Prior to 1992, the data was collected at a point just east of T.H. 100.

Data Reduction

One action was selected for inclusion in the methodology development database: Construction of the reversible HOV lane in the median in 1985, before freeway construction started.

Description: This data set shows the impacts of constructing a 4.0 mile (6.4 km) HOV lane. The HOV lane is a single reversible lane located in the median of a four lane (2 lanes each direction) signalized arterial. The signalized arterial (U.S. 12) was the last uncompleted section of the I-394 freeway. The average speed through this section can drop to 17 mph during the peak hour.

The HOV lane is split into two sections. The 3.0 mile (about 4.8 km) section of the median HOV lane moved through 4 traflic signals. The one mile section was located about one mile west of the three mile section. The one mile section had one traffic signal in the middle of it.

The median lane provided HOV's with their own exclusive lane for queuing at the signals. No turns were allowed into or out of the HOV median lane at any of the signals. Entry or exit was allowed only at the endpoint of each section of the HOV lane.

Ramp metering was not present during the periods of the before and after studies.

Travel Time Data: The available before and after travel time data was for a 7 mile long segment from I-494 to Penn Avenue that included the HOV lane.

The HOV travel time for the 4.0 mile HOV section was computed assuming that the HOV's moved at 55 mph on the freeway portions of the travel time run. The estimated HOV travel time on the non-HOV lane portions was subtracted from the total time to obtain the HOV travel time for the 4.0 mile section with the HOV lane.

The difference in travel times (SOV minus HOV) for the after case was then added to the HOV time to obtain the SOV (single occupant vehicles and other non-HOV-lane using vehicles) after time.

The "before" travel time was computed assuming that the arterial functioned as a bottleneck, thus allowing all traflic to travel at 55 mph on the freeway portions of the run.

Only average peak hour travel times were available. The maximum peak hour time was therefore assumed to be equal to the average peak hour travel time for SOV's. The HOV maximum and average travel times are assumed to be identical.

No peak period data was available.

Volume Counts: Before and after AM peak hour eastbound counts were obtained for May 1984 and May 1986 respectively.

Volume counts were not broken down by auto occupancy. The percentage breakdown by occupancy in the HOV lane was reported for the after survey. These percentages plus the reported persons per vehicle in the HOV and SOV lanes were used to derive an approximate distribution of vehicles by occupancy type.

Trucks and motorcycles were estimated for the before condition and for the after SOV lanes based upon 1986 "after" data and the split between motorcycles and trucks reported by a later 1993 data collection effort on I-394.

Bus passenger counts were obtained directly from the available reports.

The number of single occupant vehicles using the HOV lane was estimated based upon the reported "after" violation rate (5%).

No peak period data was available.

Table D-5 summarizes the results of the before/after study.

References

1. Allan Pint, Charlene Zimmer, Joseph Kern, and Leonard Palek. "Evaluation of the Minnesota I-394 HOV Transportation System," Preprint from Transportation Research Board 74th Annual Meeting, January 22-28, 1995.
2. Strgar-Roscoe-Fausch, Inc. I-394 User Assessment Survey, April 1993.
3. Strgar-Roscoe-Fausch, Inc. I-394 Interim HOV Lane: A Case Study, Phase I Report, Prepared for Minnesota Department of Transportation, October 1987.
4. Strgar-Roscoe-Fausch, Inc. I-394 Interim HOV Lane: A Case Study, Phase II Report, Prepared for Minnesota Department of Transportation, July 1990.
5. Strgar-Roscoe-Fausch, Inc. I-394 Case Study, April 1989 Survey Results, August 1990.
6. Strgar-Roscoe-Fausch, Inc. I-394 Phase III Evaluation Data Summary Report, Prepared for Minnesota Department of Transportation, September 1994.
7. Donald G. Capelle and Sharon Greene. "High-Occupancy Vehicle Lanes: An Incentive for Ridesharing?" ITE, District 6, 1988 Annual Meeting, Colorado Springs, July 1988, pp. 6-8.

Table D-4. I-394 Minneapolis HOW Facility History

Date	November 1985	1987 to 1992	October 1992
Action:	Construct 4 miles barrier separated, reversible HOV Lane in Median	Replace Expressway Signals with Freeway Interchanges. Construct Left-hand Side, Concurrent Flow HOV Lanes	Construct 2 lane barrier separated, reversible HO\ Facility in Median of Freeway
Included in Before/After Data Set?	YES	NO[9]	NO[10]
Corridor	us 12	T.H. 101 toT.H. 100	T.H. 100 to I-94
# of HOV lanes	1 lane reversible	1 lane in each direction	2 lanes reversible
# of general purpose lanes	2 lanes each direction	2 lanes in each direction	2 lanes in each direction
Length	3 miles - e/o T.H. 100 1 mile - Plvmouth Road	8 miles	3 miles
HOV Eligibility	2+	2+	
Hours of HOV Operation	6:00 to 9:00 am EB 2:00 to 7:00 pm WB	6:00 to 10:00 am EB 2:00 to 8:30 pm WB	6:00 to 10:00 am EB 2:00 to 8:30 pm WB
Type of facility	barrier-separated reversible, on signalized expressway	concurrent lanes on freeway	barrier separated reversible on freeway
Ramp Metering	no	8 ramp meters with HOV bypass lanes	
Park-and-ride facilities	6 park and ride lots	7 park and ride lots	
Other support facilities	1 downtown parking lot for registered carpools, public information program	Automated traffic management system, 3 downtown parking garages, skyways, 3 transit transfer stations, rideshare program, marketing program	
Bus Service	Addition of express bus service to downtown	Expanded express and timed-transfer local bus service	

9 The available "before and after" data for this action has not been included in the methodology development database because the HOV lane action occurred at about the same time as the replacement of signalized intersections with freeway interchanges. In addition, the freeway construction occurred over a four year period (April 1987 to October 1992) thus making the available "before" data a little too old to be reliable.

10 This action also occurred at same time as freeway construction, thus it has not been included in the methodology development database.

Table **D-5. Before/After Results for I-394, Minneapolis Expressway HOV Lanes**

Action: Construct 4 miles barrier separated, reversible HOV Lane in Expressway Median"		
	Peak Hour	Peak Period
HOV Lane Volume (After)	440	-
Change in Total Vehicles[12]	+6%	-
Change in Total Persons"	+12%	
Average Vehicle Occupancy[14]: Before: After:	 1.38 1.45	 - -
C h a in HOV Time"	Save 8 minutes	
Change in SOV Time[16]	Save 3 minutes	

11 Data is for morning peak period, eastbound direction. Before data gathered 18 months before opening, After data gathered 6 months after opening. Note that bus service was expanded (12/85), carpool matching efforts expanded (1986), and a free parking lot for carpools was constructed downtown (1 l/85) just prior to the HOV lane opening. All of these events occurred between the "before" study in May 1985 and the "after" study in May 1986, and probably influenced the results. Ramp metering was not present during the before or after studies.

l2 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

13 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

l4 Total persons divided by total vehicles. Includes buses and vans.

15 Mean time savings for HOV lane vehicle expressed as "Before" minus "After.

l6 Mean time savings for mixed flow lane drivers expressed as "before" minus "after.

D.3 METRO - HOUSTON, TEXAS

Houston has HOV facilities operating on five of the city's freeways that are part of a planned 96-mile HOV network, Figure D-2 shows the existing and planned network of HOV lanes surrounding downtown Houston. The system is a joint effort between the Metropolitan Transit Authority of Harris County (METRO) and the Texas State Department of Highways and Public Transportation (SDHPT). METRO is responsible for the daily operations and enforcement on the HOV lanes, or transitways. Table D-6 summarizes the facility characteristics of the HOV lanes in the Houston system. The Houston transitways are one-lane reversible facilities located in the median of the freeway and separated from the mixed-flow traffic by concrete barriers. The HOV lanes are part of a larger system that includes transit centers, park-and-ride lots, and park-and-pool staging lots. Carpool incentives, parking incentives, and flexible work hours are all part of the trip reduction program.

The first HOV facility in Houston was the North Freeway (I-45) contra-flow lane for authorized 8+ passenger vanpools and buses in 1979. This facility introduced Houston drivers to the concept of HOV lanes. Due to its success, the current system was developed. The North Freeway Contra-flow lane was replaced by the barrier separated reversible North Transitway in November 1984.

The occupancy requirement has varied from buses and authorized 8+ passenger Vanpools to the existing 2+ person per vehicle. Over the years in response to the desire to increase the transitway usage, the occupancy requirements have been lowered and the authorization requirement was eliminated. When the Gulf and Northwest Transitways became operational in July and August 1988, the 2+ occupancy requirement was used. The North Transitway and the newer Southwest Transitway also require 2 or more persons per vehicle. The Katy Transitway is one of the only HOV facilities that has varying occupancy requirements.

The Katy Transitway opened in October 1984 to authorized 8+ person vanpool and buses, but the requirements changed over time. After dropping occupancy requirements to 2+ persons per vehicle, the operations of the Katy Transitway were negatively impacted. A.M. peak hour volumes reached 1,500 vehicles per hour and travel speeds dropped, travel times increased, and travel times were no longer as reliable. In response, the peak hour occupancy requirement was raised back to 3 + persons per vehicle during the A.M. peak period and subsequently, the PM peak period.

The Texas Transportation Institute (TTI) is in charge of preparing quarterly reports of HOV lane data. TTI has been monitoring the effects of allowing Carpools on the transitways since their inception. Combining transitway operations data with Carpool surveys, TTI has amassed a great deal of data on the transitways.

Comprehensive surveys have been performed by TTI for the Katy, Northwest and Gulf Freeway corridors. A limited amount of survey data is available for the North Freeway corridor. Surveys were conducted on the Katy Freeway every year since its opening from 1985 to 1989. The Northwest and Gulf Freeways were surveyed in 1988 and 1989. The North Freeway was surveyed once in 1986. TTI has summarized this data in a report.17

The purpose of the surveys was to determine the impacts of allowing Carpools on the transitways and to measure public sentiment towards HOV facilities. Survey questionnaires were distributed periodically to both HOV users and non-users from license plate numbers collected during the a.m. peak period on each of the facilities. The response rate ranged from 29% to 42% of the surveys mailed. The survey included personal characteristics, travel patterns and trip characteristics, and attitudes and impacts pertaining to transitways.

Contact: Mr. Dick McCasland, Texas Transportation Institute , Tel: (713) 686-2971

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17 Diane L. Bullard ***A summary of Survey Data from the Katy, North, Northwest and Gulf Transitways, April 198.5 Through October*** 1989. Texas Transportation Institute for the Texas State Department of Highways and Public Transportation, Research Report 484- 12, July 1990.

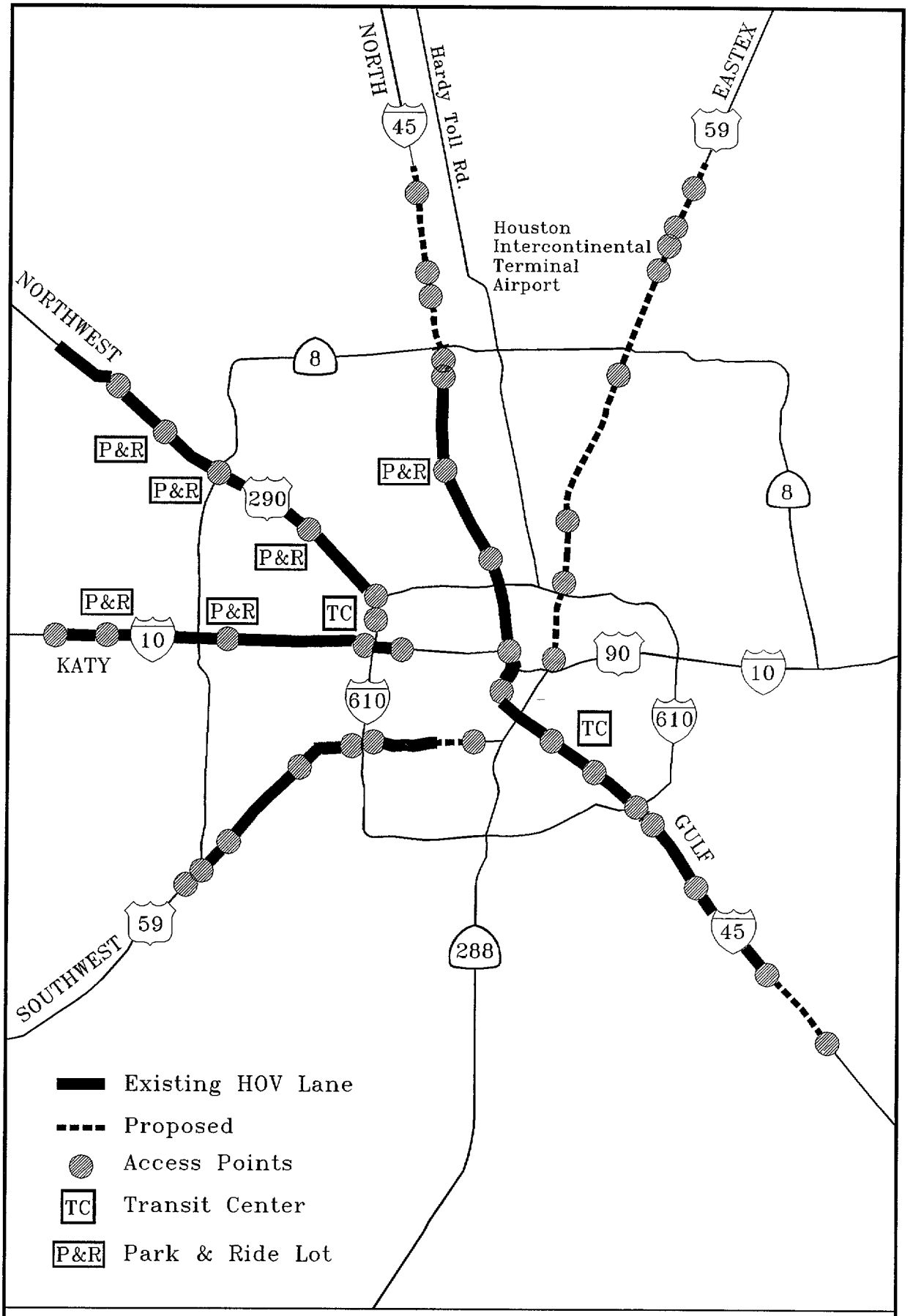

Figure D-2
HOV Facilities in the Houston Area

94044/figD-2.DWG 5-28-96

Table D-6. Houston Freeway HOV Characteristics

Characteristics	Texas - Houston				
Corridor	Katy I-10	North I-45	Northwest US290	Gulf I-45	Southwest us59
# of lanes	1	1	1	1	1
Length (mi.)	13	13.5	13.5	12.1	11.5
Date Operational	84/90	79/90	88	88/94	
HOV Eligibility	3+ peak hrs 2+ other	2+	2+	2+	2+
Hours of HOV Operation (weekday only)	5am-12noon 2-9pm	5am-12noon 2-9pm	5am-12noon 2-9pm	5am-12noon 2-9pm	5am-12noon 2-9pm
Type of facility (barrier sep. 2-way, reversible flow, concurrent, etc.)	barrier separated reversible	barrier separated reversible	barrier separated reversible	barrier separated reversible	barrier separated reversible
Park-and-ride facilities	3 lots (3,500+ spaces)	3 lots (3,500+ spaces)	3 lots (3,500+ spaces)	3 lots (3,500+ spaces)	3 lots (3,500+ spaces)
Ramp Metering	None	None	None	None	None
Other support facilities	park-and-pool staging lots	park-and-pool staging lots	park-and-pool staging lots	park-and-pool staging lots	park-and-pool staging lots
Bus Service	Express service	express service	express service	express service	express service

Sources:

1. Tumbull, Katherine. An Assessment of High-Occupancy Vehicle Facilities in North America: Executive Report, Texas Transportation Institute, August 1992, Table 1. General Characteristics of Operating HOV Facilities.
2. Fuhs, Charles. Inventory of Existing and Proposed High-Occupancy Vehicle Projects, June 1994.

D.3.1 Traveler Survey Results

Survey of transitways users and non-users were conducted from 1986 to 1990. Users included both bus patrons and carpool/vanpool users. Results of these surveys when compared to 1981 and 1984 data show an increase in actual and perceived use of the facility that is not at the expense of other transit modes. The survey included previous mode of travel, trip purposes, trip origin and destination, perceptions of utilization and attitudes towards the HOV lanes. From the results of the survey work, it was estimated that about 50% of the carpoolers have chosen to carpool or ride the bus since the opening of the HOV facility. A look at the results of the previous mode of travel indicate that carpoolers who previously drove alone increased from 40% in 1988 to 60% in 1990.

The following figures show the proportions of HOV drivers that came from other modes for the North and Northwest transitways. These two surveys were collected soon after the opening of the HOV lane in the Northwest Corridor or soon after the conversion of the North Transitway from 3+ to 2+ operation. Figure D-3 shows the previous modes of HOV drivers using the North Freeway in 1990. Figure D-4 shows the previous modes of HOV drivers using the Northwest Freeway in 1990.

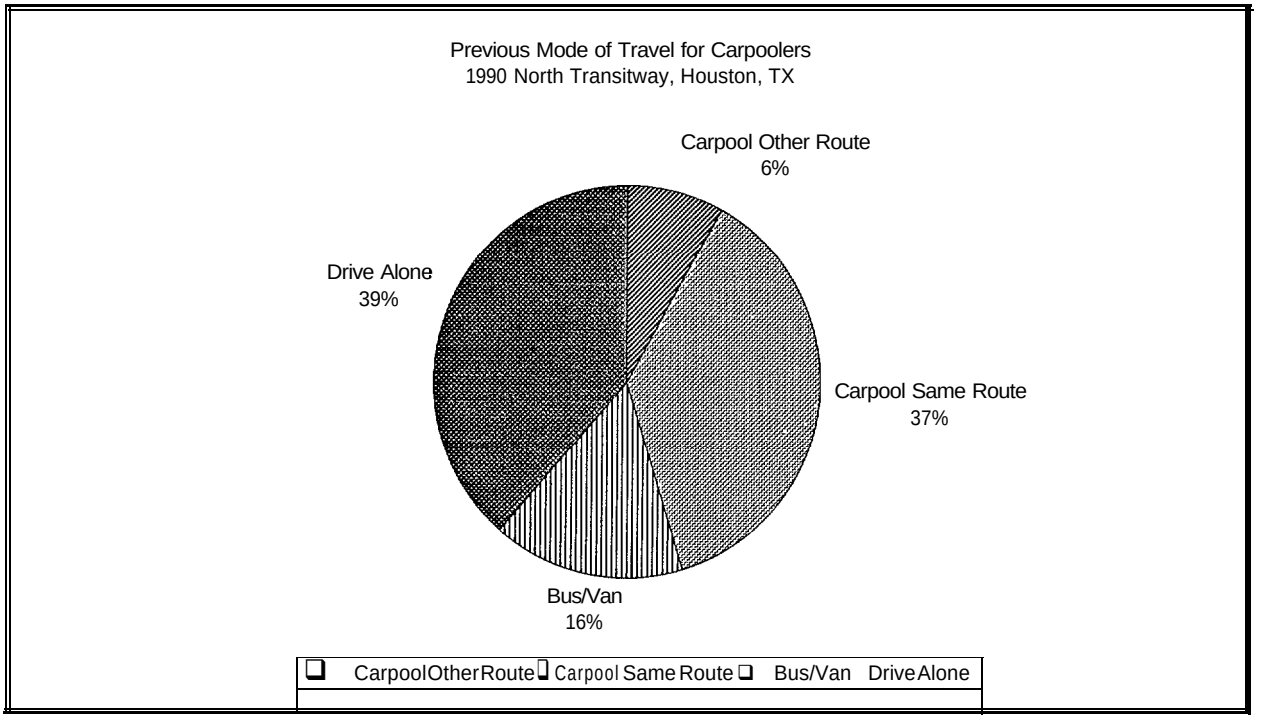

Figure D-3 Previous Mode of North Transitway Carpoolers.

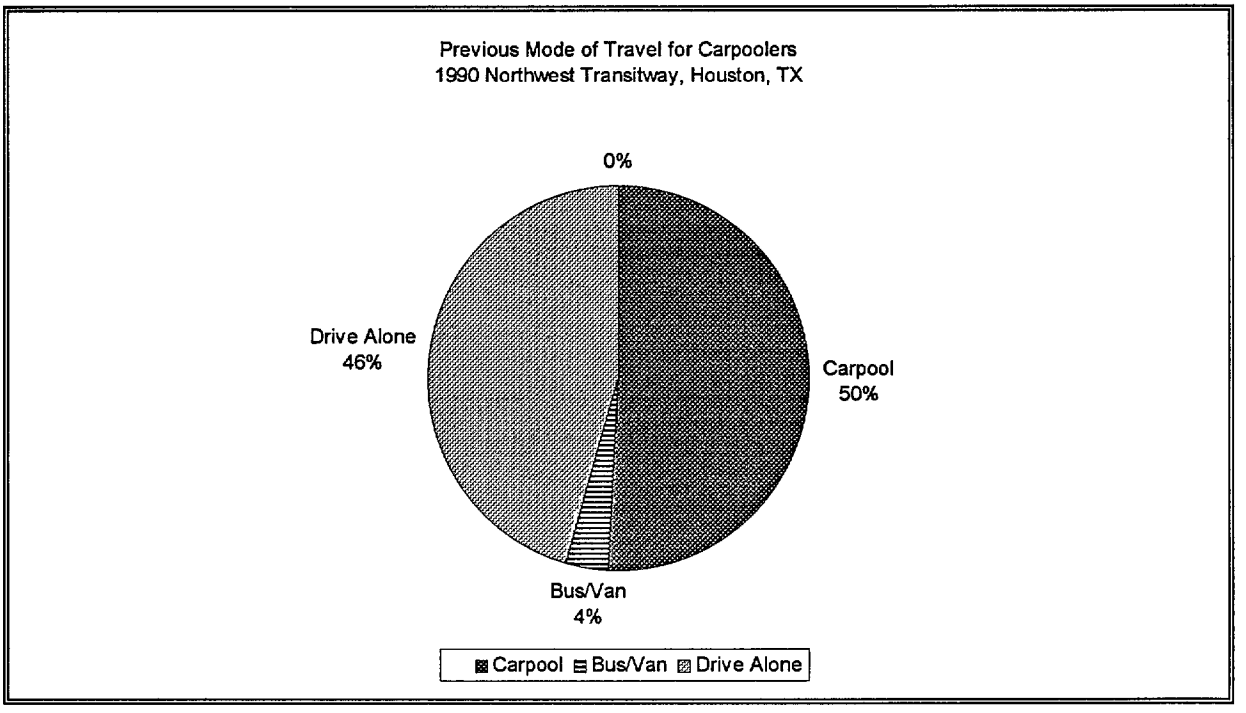

Figure D-4 Previous Mode of Northwest Transitway Carpoolers.

D.3.2 Katy Freeway (I-10 West) - Houston, Texas

The Katy Freeway HOV lane is a 13-mile, one-lane, barrier-separated, reversible facility on the west side of Houston. Access and egress are provided by both slip ramps and grade-separated, direct access ramps at five points along the corridor. Three park-and-ride lots and three park-and-pool lots are located in the corridor. The HOV lane was opened in stages between 1984 and 1990. The current hours of operation are from 5:00 am to 12:00 noon inbound and 2:00 pm to 9:00 pm outbound. The Katy transitway also operates during the weekend.

Project History

The Katy HOV facility opened in 1984 to buses and authorized vanpools exclusively (See Table D-7). Its initial length was 4.7 miles (7.6 km). In April 1985, the requirement was dropped to 4+ carpools with pre-authorization. The facility was extended another 1.7 miles (2.7 km) in May 1985. In December 1985, the requirement was dropped to 3+ carpools with prior authorization. The authorization requirement was dropped and the occupancy requirement was further reduced to 2+ in August 1986. The facility was extended another 5.1 miles (8.2 km) in June 1987. In response to a degradation in the travel times on the HOV lane, the requirement was changed in October 1988 back to 3 + occupancy during the peak morning commute period from 6:45 am to 8:15 am, while remaining at 2+ person during all other hours of operation. The facility was extended another 1.2 miles (1.9 km) in January 1990. In September 1991, the 3+ requirement was also imposed during the PM peak period from 5:00 to 6:00 pm. The Katy Transitway is the only HOV facility that changes occupancy requirements by time of day.

Selection of Before/After Data Sets

The above history suggests the following distinct HOV facility actions that could be candidates for inclusion in the methodology development database:

1. Construction of 4.7 mile Transitway October 29, 1984.

2. 4+ Carpools allowed (4/1/85).
3. HOV extended 1.7 miles (5/2/85.
4. 3+ carpools allowed (1 l/4/85).
5. 2+ carpools allowed, longer hours of operation (8/l l/86).
6. HOV extended 5.1 miles (6/29/87).
7. Longer hours of operation (7/25/88).
8. Only 3+ cat-pools allowed 6:45 AM to 815 AM, 2+ allowed other times (10/17/88).
9. HOV extended 1.2 miles (l/9/90).
10. Northwest Transit Center opens (4/l/90).
11. 3+ carpool hours changed to 6:45 AM to 8:00 AM (5/23/90).
12. Only 3+ carpools allowed 5:00 PM to 6:00 PM (9/16/91).

Actions # 5,6, 8, 9 were selected for before/after studies. Prior to action #5, every action related to a bus/Vanpool or pre-authorized HOV facility. These conditions are not comparable to the majority of the HOV facilities elsewhere in the country and therefore have not been included in the proposed new methodology database. Similarly, actions #7, 10, 11, and 12 have not been included in the before/after data set because of the lack of similar data elsewhere and the likelihood that the new methodology (being a quick response method) will not be sensitive to minor impacts caused by changes in hours of operation or the construction of a new transit center.

Data Collection

The Texas Transportation Institute (TTI) has conducted comprehensive before-and-after studies and continues to monitor the Katy and other transitways. Data includes person movements, vehicle counts, travel times, speeds, vehicle occupancy, Carpool volumes, travel behavior studies, bus service, park-and-ride utilization, and bus utilization. In the reports, the data are separated into HOV, non-HOV, and transit.

The volume counts are taken from trend line graphs of the person movements and vehicle utilization for the HOV lane and the freeway mainline.

Survey of transitways users and non-users were conducted from 1985 to 1990. Users included both bus patrons and carpool/vanpool users.

Data Reduction

Description: This data set consists of four before/after data sets showing:

A. The impacts of converting a 6.4 mile (10.3 km) median, reversible HOV lane from buses and pre-authorized 3+ carpools to 2+ carpools, with the Carpools no longer required to obtain a permit before using the lane.
B. The impacts of extending a median, reversible HOV lane (with 2+ carpools and buses allowed) by 5.0 miles (8.1 km).
C. The impacts of converting a 5.0 mile (8.1 km) long median, reversible HOV lane from 2+ carpools to 3+ Carpools.
D. The impacts of extending a median, reversible HOV lane (with 3+ carpools and buses allowed) by 1.2 miles (1.9 km).

The HOV lane is a single reversible lane located in the median of an eight lane (4 lanes each direction) freeway. The average speed over the length of the section can drop to as low as 23 mph during the peak period. Access to the HOV lane is limited to its starting and endpoints plus selected mid-points.

Travel Time Data: The earliest available travel time data was collected in 1991 for a 13 mile long segment. Travel time data was reported by 15 minute period for the entire peak period. No before and after data was available.

The SOV travel time was computed using the reported SOV average speed for 1991. Before and after SOV times were assumed to be unchanged.

The computation of before and after HOV travel times varied by action. The SOV travel times were assumed to be unaffected by each action.

Action "A" (Convert 3+ to 2+): The HOV travel time for the HOV section was computed assuming that the HOV's moved at 55 mph. Before and after HOV times were assumed to be unchanged

Action "B" (Extend 5 miles): The HOV travel time for the HOV lane section was computed assuming that the HOV's moved at 55 mph. Before HOV times were computed assuming that HOV's moved at the same speed as SOV's on the non-HOV lane section of the freeway.

Action "C" (Convert 2+ to 3+): The HOV travel time for the HOV section was computed assuming that the HOV's moved at 55 mph. Before and after HOV times were assumed to be unchanged

Action "D" (Extend 1.2 miles): The HOV travel time for the HOV lane section was computed assuming that the HOV's moved at 55 mph. Before HOV times were computed assuming that HOV's moved at the same speed as SOV's on the non-HOV lane section of the freeway.

The before/after results for each of the above four actions are shown in Table D-8, Table D-9, Table D-10, and Table D-11.

Volume Counts: Before and after AM peak hour eastbound counts were obtained for April 1986 and April 1987 respectively.

Volume counts were obtained from monthly graphs of total vehicle volumes, 2+ Carpools, 3+carpools, vans, and buses using the HOV lane and the mixed flow lanes. No truck or motorcycle data was reported. Bus passenger counts were obtained directly from the available reports. The number of single occupant vehicles using the HOV lane was reported be less than 5%, so this percentage was used to estimate the number of SOV's in the HOV lane.

Table D-7. Katy Freeway History and Characteristics

Date:	10/29/84	4/1/85	5/2/85	11/4/85	8/11/86	6/29/87	10/17/88	May 1990
Action:	Construct 4.7 miles	Allow 4+	Extend 1.7 miles	Allow 3+	Allow 2+	Extend 5.1 miles	Convert to Partial 3+	Extend 1.5 miles
Included in Before/After Data Set?	No	No	No	No	Yes	Yes	Yes	Yes
Limits	Post Oak to Gessner		Post Oak to West Belt			Post Oak to S.H. 6		S.H. 6 to Washington
# of HOV lanes	1 lane reversible							
# of general purpose lanes	3 lanes in each direction							
Length	4.7	4.7	6.4	6.4	6.4	11.5	11.5	13 miles
HOV Eligibility	Buses and vanpools	4 + carpool with authorization		3 + carpool with autho-rization	2 + carpool	2+ carpool	3 + (peak) and 2+ (other)	
Hours of HOV Operation	5:00 am to 12:00 noon 2:00 pm to 9:00 pm							
Type of facility	Barrier-separated, reversible							
Ramp Metering	None	None	None	None	None	None	None	None
Park-and-ride facilities	Addicks (1981)	West Belt 1,111 spaces (1984)	Kingsland 1,326 spaces (1985)				Addicks Expansion 1,155 spaces (1988)	
Other support facilities					3 "park-and-pool" staging lots			
Bus Service	Express service from park-and-ride lots and major collector routes, bus transfer centers, Northwest Transit Center (1990)							

Sources:

1. Diane L. Bullard. "Analysis of Carpool Survey Data from the Katy, Northwest, and Gulf Transitways in Houston, Texas," Transportation Research Record 1321, pp. 73-81.
2. Diane L. Bullard. A Summary of Survey Data for the Katy, North, Northwest, and Gulf Transitways, April 1985 through October 1989. Texas Transportation Institute, July 1990.
3. Montie G. Wade, Dennis Christiansen, and Daniel E. Morris. An Evaluation of the Houston High-Occupancy Vehicle Lane System. Texas Transportation Institute, Research Report 1146-5, August 1992. Appendix A.

Table D-8. Action "A", Katy Transitway Results

Action: Convert 3+ pre-authorized to 2+ unauthorized[18]		
	Peak Hour	Peak Period
HOV Lane Volume (After)	1400	**2570**
Change in Total Vehicles"	+ll%	+10%
Change in Total Persons[20]	+57%	**+41%**
Average Vehicle Occupant[21] : Before: After:	 1.48 **1.63**	 1.34 **1.42**
Change in HOV Time[22]	Save 8 minutes	Save 4 minutes
Change in SOV Time[23]	Save 0 minutes **(est.)**	Save 0 minutes (est.)

Table D-9. Action "B", Katy Transitway Results

Action: Extend HOV Facility 5.1 miles[24]		
	Peak Hour	Peak Period
HOV Lane Volume (After)	1410	**2930**
Change in Total Vehicles	+13%	+13%
Change in Total Persons	**+9%**	**+15%**
Average Vehicle Occupancy: Before: After:	 1.63 **1.57**	 1.42 **1.45**
Change in HOV Time	Save 7 minutes	Save 3 minutes
Change in SOV Time	Save 0 minutes (est.)	Save 0 minutes (est.)

18 Data is for morning peak period (6:00 AM to 9:30 AM), eastbound direction. Before data gathered 4 months before opening, After data gathered 8 months after opening.

19 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

20 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

21 Total persons divided by total vehicles. Includes buses and vans,

22 Mean time savings for HOV lane vehicle expressed as "Before" minus "After. Estimated from 1991 data.

23 Mean time savings for mixed flow lane drivers expressed as "before" minus "after. Estimated from 1991 data.

24 Data is for morning peak period (6:00 AM to 9:30 AM), eastbound direction. Before data gathered 3 months before opening, After data gathered 9 months after opening.

Table D-l 0. Action "C", Katy Transitway Results

Action: Convert 2+ to 3+ during peak of peak period[25]		
	Peak Hour	Peak Period
HOV Lane Volume (After)	880	1930
Change in Total Vehicles[26]	+6%	+11%
Change in Total Persons[27]	+8%	+10%
Average Vehicle Occupant[28].		
Before:	1.57	1.45
After:	1.61	1.43
Change in HOV Time[29]	Lose 14 minutes	Lose 7 minutes
Change in SOV Time[30]	Save 0 minutes (est.)	Save 0 minutes (est.)

Table D-l 1. Action "D", Katy Transitway Results

Action: Extend HOV facility 1.5 miles (1.2 miles in eastbound direction, 1.5 miles in westbound direction)[31]		
	Peak Hour	Peak Period
HOV Lane Volume (After)	1160	2830
Change in Total Vehicles	+8%	+4%
Change in Total Persons	+11%	+7%
Average Vehicle Occupancy		
Before:	1.61	1.43
After:	1.64	1.47
Change in HOV Time[32]	Save 1 minutes	Save 0 minutes
Change in SOV Time	Save 0 minutes (est.)	Save 0 minutes (est.)

25 Data is for morning peak period (6:00 AM to 9:00 AM), eastbound direction. Before data gathered 6 months before opening, After data gathered 6 months after opening.

26 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

27 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

28 Total persons divided by total vehicles. Includes buses and vans.

29 Mean time savings for 2 person HOV vehicles expressed as "Before" minus "After. Estimated from 1991 data. Lost time reflects that 2 person HOV's now must use mixed flow lanes.

30 Mean time savings for mixed flow lane drivers expressed as "before" minus "after. Estimated from 1991 data.

31 Data is for morning peak period (6:00 AM to 9:30 AM), eastbound direction. Before data gathered 8 months before opening, After data gathered 4 months after opening.

32 Mean time savings for HOV lane vehicle expressed as "Before" minus "After. Estimated from 1991 data. Rounded to nearest whole minute.

D.3.3 North Freeway (I-45) - Houston, Texas

The North Freeway serves the rapidly growing northern Harris County and Montgomery County to the north of downtown Houston. The North Freeway HOV lane is a 13.5-mile barrier-separated, reversible facility in the median of I-45 North. The HOV lane can be accessed at six points along the corridor. The HOV lanes are in operation from 5:00 am to 12:00 noon inbound and 2:00 pm to 9:00 pm outbound. The current facility is restricted to vehicles with two or more persons. Four park-and-ride lots are located in the vicinity of the HOV facility.

Project History

The original HOV lane on I-45 North was a 9.1 mile (14.7 km) contraflow facility that opened in August 1979 (see Table D-12). The contraflow facility was intended as an interim improvement until the flows in the off-peak direction gained enough to offset the initial 70 to 30 directional split. Travel time savings of 15 minutes were realized on the contraflow facility. After one year of operation, the peak period passenger trips increased from 1,450 to 4,600.

The contraflow facility operated through-out construction of the transitway, from January to November 1984, when it was replaced by a 9.1 mile reversible flow lane in the median (the transitway).

Between June 1987 and June 1988 the freeway was widened from 3 to 4 mixed-flow lanes in each direction.

The transitway was extended 4.4 miles (7.1 km) in April 1990.

Two person Carpools were allowed on the transitway on June 26, 1990.

Plans call for extending the HOV lane further north to FM 1960. Once completed the North Freeway HOV lane will extend from downtown Houston to FM 1960 for a total of 19.7 miles.

Selection of Before/After Data Sets

The following actions were identified for this facility:

1. Construction of Contraflow lanes (8/29/79).
2. Replacement with reversible flow lane in median (1 l/23/84).
3. Extension of 4.4 miles (4/2/90).
4. 2+ carpools allowed (6/26/90).

All of these actions, except for the last action, applied when the transitway operated as abusway with Vanpools allowed. The last action, allowing 2+ Carpools, is equivalent to opening a new HOV lane in most other states. Consequently, only the last action of allowing 2+ Carpools will be included in the methodology development database.

Data Collection

The data collected for the North Freeway focuses on the barrier separated HOV facility. Limited data is available for the contraflow facility. Similar to the data for the Katy Freeway, the data for the North Freeway include person movements, vehicle counts, travel times, speeds, vehicle occupancy, Carpool volumes, travel behavior studies, bus service, park-and-rode utilization, and bus utilization.

The data collection effort did not include the contraflow and concurrent flow facilities that were in place prior to the construction of the barrier-separated, reversible flow lane in the median. Limited pre-contraflow "before" condition data is available since the data was not collected prior to the opening of the contraflow facility in 1979.

The volume counts are taken from trend line graphs of the person movements and vehicle utilization for the HOV lane and the freeway mainline. Both A.M. and P.M. peak hour and peak period data are available.

Data Reduction

Description: This data set shows the impacts of converting a 13.5 mile (2 1.7 km) median, reversible HOV lane from buses and pre-authorized 3+ carpools to 2+ car-pools, with the Carpools no longer required to obtain a permit before using the lane. The HOV lane is a single reversible lane located in the median of an eight lane (4 lanes each direction) freeway. The average speed over the length of the section can drop to as low as 37 mph during the peak period.

The conversion took effect June 26, 1990.

Access to the HOV lane is limited to its starting and endpoints plus few points in between.

Travel Time Data: The earliest available travel time data was collected in 1991 for a 13 mile long segment. Travel time data was reported by 15 minute period for the entire peak period. No before data was available.

The HOV travel time for the HOV section was computed assuming that the HOV's moved at 55 mph. Before and after HOV times were assumed to be unchanged.

The SOV travel time was computed using the reported SOV average speed for 199 1. Before and after SOV times were assumed to be unchanged.

Volume Counts: Before and after AM peak hour south-eastbound counts were obtained for May 1990 and May 1991 respectively.

Volume counts were obtained from monthly graphs of total vehicle volumes, 2+ Carpools, vans, and buses using the HOV lane. Only total vehicle and person volumes were available for the mixed flow lanes (no breakdown by occupancy). The split between 2, 3, and 4+ Carpools was estimated assuming 90% 2-person, 9% 3-person, and 1% 4+person (similar to the Katy freeway observations). No van data was reported.

No truck or motorcycle data was reported.

Bus passenger counts were obtained directly from the available reports.

The number of single occupant vehicles using the HOV lane was assumed to be 5% of the HOV volume.

Table D-13 summarizes the results of the before/after study.

Sources

1. Diane L. Bullard. "Analysis of Carpool Survey Data from the Katy, Northwest, and Gulf Transitways in Houston, Texas," Transportation Research Record 132 1, pp. 73-8 1.
2. Diane L. Bullard. A Summary of Survey Data for the Katy, North, Northwest, and Gulf Transitways, April 1985 through October 1989. Texas Transportation Institute, July 1990.
3. Hana M. Kuo. The North Freeway Transitway: Evaluation of the First Year of Barrier-Separated Operation. Texas Transportation Institute, Research Report 339-9, February 1987.
4. Montie G. Wade, Dennis Christiansen, and Daniel E. Morris. An Evaluation of the Houston High-Occupancy Vehicle Lane System. Texas Transportation Institute, Research Report 1146-5, August 1992. Appendix "B".

Table D-12. North Freeway HOV Facility History and Characteristics

CCharacteristic	North Freeway HOV System			
Date:	Aug 79	Nov 84	Apr 90	Jun 90
AAction:	Construct Contra-flow Lane	Construct Reversible Lane	Extend 4.4 miles	Convert to 2+
IIInclude in Before/After Data Set	No	No	No	Yes33
CCorridor	Downtown to N. Shepherd Dr.	Downtown to N. Shepherd Dr.	Downtown to Beltway 8	Downtown to Beltway 8
# of HOV lanes	1	1	1	1
# of gen. purpose lanes		4 in each dir.	4 in each dir.	4 in each dir.
Length	9.6	9.6	13.5	13.5
HOV Eligibility	buses and 8+ vanpools only			2+ pools
Hours of HOV Operation	6 to 8:30 am 4 to 6:30 pm	6 to 8:30 am 4 to 6:30 pm	5 am to 12 noon 2 pm to 9 pm	5 am to 12 noon 2 pm to 9 pm
Type of facility	contraflow	barrier separated reversible	barrier separated reversible	barrier separated reversibl
Ramp Metering	yes, for off- peak dir. flow	None	None	None
Park-and-ride facilities	Champions (8/79 - 10/82) Greenspoint (8/79 - 11/79) Aldine Stad. (11/79 - 1/80) N. Shepherd (750 spaces) Kuykendahl (1,300 spaces)	N.Shepherd Expansion (1,605 total spaces) Spring (1,280 spaces) Kuykendahl Expansion (2,256 total spaces) Seton Lake (1,286 spaces)		Woodlands Expansion (1991)
Bus Service	Increase bus service	No dramatic increase in additional service		

33 All actions prior to conversion to 2+ operation excluded from database because they apply only to busway (with vans) operation. Bus patronage and frequency forecasting requires different methodology than for 2+ carpools.

Table D-13. North Transitway Results

Action: Convert to 2+ Carpool operation[34]		
	Peak Hour	Peak Period
HOV Lane Volume (After)	830	-
Change in Total Vehicles[35]	-3%	%
Change in Total Persons[36]	+7%	- %
Average Vehicle Occupancy[37]: Before: After:	 1.45 1.60	
Change in HOV Time[38]	Save 6 minutes	Save 0 minutes
Change in SOV Time[39]	Save 0 minutes (est.)	Save 0 minutes (est.)

34 Data is for morning peak period (6:00 AM to 8:45 AM), southbound direction. Before data gathered 1 month before opening, After data gathered 11 months after opening.

35 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

36 Total persons in peak direction in all vehicles, in ail lanes expressed as "After" minus "before", divided by "before".

37 Total persons divided by total vehicles. Includes buses and vans.

38 Mean time savings for HOV lane vehicle expressed as "Before" minus "After. Estimated from 199 1 data. Rounded to nearest whole minute.

39 Mean time savings for mixed flow lane drivers expressed as "before" minus "after. Estimated from 1991 data.

D.3.4 Northwest Freeway (US 290) - Houston, Texas

The Northwest Freeway HOV lane is a 13.5-mile, one-lane, barrier-separated, reversible facility on the north side of Houston. The HOV lane was opened in 1988 to vehicles with two or more occupants. Access and egress are provided by both skip ramps and direct access ramps at six points along the corridor. The hours of operation are from 4:00 am to 1:00 pm inbound and 2:00 pm to 10:00 pm outbound.

Project History

The first 9.5 mile (15.3 km) segment of the transitway opened on August 29, 1988 (see Table D-14). The lane was extended 4 miles on February 6, 1990. It has always operated as a 2+ person carpool facility.

Selection of Before/After Data Sets

The opening of the new transitway in August 1988 was selected for inclusion in the methodology development database. The later extension of the transitway occurred within two months of the opening of the Northwest Transit Center which would have confused the results. Consequently this latter action was not included in the database.

Data Collection

The Texas Transportation Institute (TTI) has conducted comprehensive before-and-after studies and continues to monitor the Northwest and other transitways in Houston. Data includes person movements, vehicle counts, travel times, speeds, vehicle occupancy, car-pool volumes, travel behavior studies, bus service, park-and-ride utilization, and bus utilization. In the reports, the data are separated into HOV, non-HOV, and transit.

Vehicle count data is available for the Hempstead Highway which parallels the Northwest Freeway along the railroad tracks from downtown Houston. This is one of the parallel facilities for which data is collected.

The volume counts are taken from trend line graphs of the person movements and vehicle utilization for the HOV lane and the freeway mainline. Both A.M. and P.M. peak hour and peak period data are available.

Data Reduction

Description: This data set shows the impacts of constructing a 9.5 mile (15.3 km) median, reversible HOV lane (with 2+ carpools and buses allowed). The HOV lane is a single reversible lane located in the median of an six lane (3 lanes each direction) freeway. The average speed over the length of the section can drop to as low as 30 mph during the peak period.

Access to the HOV lane is limited to its starting and endpoints and a few other points.

Travel Time Data: The earliest available travel time data was collected in 1991 for a 13 mile long segment. Travel time data was reported by 15 minute period for the entire peak period. No before and after data was available.

The HOV travel time for the HOV lane section was computed assuming that the HOV's moved at 55 mph. Before HOV times were computed assuming that HOV's moved at the same speed as SOV's on the non-HOV lane section of the freeway.

The SOV travel time was computed using the reported SOV average speed for 199 1 Before and after SOV times were assumed to be unchanged.

Volume Counts: Before and after AM peak hour southbound counts were obtained for April 1989 and April 1990 respectively.

Volume counts were obtained from monthly graphs of total vehicle volumes, 2+ carpools, vans, and buses using the HOV lane. Only total vehicle and person volumes were available for the mixed flow lanes (no breakdown by occupancy). The split between 2, 3, and 4+ carpools was estimated assuming 90% 2-person, 9% 3-person, and 1% 4+person (similar to the Katy freeway observations). No van data was reported.

No truck or motorcycle data was reported.

Bus passenger counts were obtained directly from the available reports.

The number of single occupant vehicles using the HOV lane was assumed to be zero.

The results of the before/after study are summarized in Table D-15

Sources

1. Diane L. Bullard. "Analysis of Carpool Survey Data from the Katy, Northwest, and Gulf Transitways in Houston, Texas," Transportation Research Record 1321, pp. 73-81.
2. Diane L. Bullard. A Summary of Survey Data for the Katy, North, Northwest, and Gulf Transitways, April 1985 through October 1989. Texas Transportation Institute, July 1990.
3. Montie G. Wade, Dennis Christiansen, and Daniel E. Morris. An Evaluation of the Houston High-Occupancy Vehicle Lane System. Texas Transportation Institute, Research Report 1146-5, August 1992. Appendix "D".

Table D-14. Northwest Freeway HOV Facility History and Characteristics

Characteristic	Northwest Freeway HOV System	
Date:	8/29/88	2/6/90
Action:	Construct HOV lane	Extend HOV lane 4 miles
Included in Before/After Data Set?	Yes	No[40]
Limits:	Northwest Transit Center to Little York	Northwest Transit Center to FM 1960
# of HOV lanes	1	1
# of general purpose lanes	3 lanes in each direction	3 lanes in each direction
Length	9.5	13.5
HOV Eligibility	2+	2+
Hours of HOV Operation	4:00 am to I:00 pm inbound 2:00 pm to 10:00 pm outbound	4:00 am to 1:00 pm inbound 2:00 pm to 10:00 pm outbound
Type of facility	barrier separated reversible	barrier separated reversible
Ramp Metering	None	None
Park-and-ride facilities	Northwest Station (1984) W. Little York (1988) Pinemont (1989)	Northwest Station Modification (1990)
Bus Service	Northwest Transit Center opened 4/l/90	

[40] Excluded because transit center also opened within 2 months of HOV lane extension.

The HOV peak hour volume breakdown by occupancy was estimated based upon the mixed flow occupancy data, assuming that motorcycles, trucks, and buses in the lanes could be neglected. Single occupant vehicle use of the HOV lanes was also assumed to be negligible based upon the reported 1.5% violation rate.

The distribution of volumes by vehicle occupancy and vehicle type was assumed to be identical for the peak period and the peak hour. (However, the necessary data was reported by 15 minute period, should it be desirable to check this assumption)

Bus passenger counts were reported only on a daily basis for buses using the HOV lanes. This daily ridership was assumed to occur totally in the peak period. The peak period ridership was divided by 2 to obtain peak hour ridership. The ridership was then assigned to the HOV lanes and the mixed flow lanes in proportion to the number of buses using each facility.

The number of single occupant vehicles using the HOV lane was assumed to be zero.

Table D-19 summarizes the results of the before/after study.

Sources:

J.S. Supernak. Assessment of the Effectiveness of the Reversible Roadway for High Occupancy Vehicles on Interstate Route 15. San Diego State University, Department of Civil Engineering, San Diego, California, May 1991,

Part 2 - Volume/Occupancy Study,

Part 3 - Speed/Delay Study,

Part 6 - Bus Study.

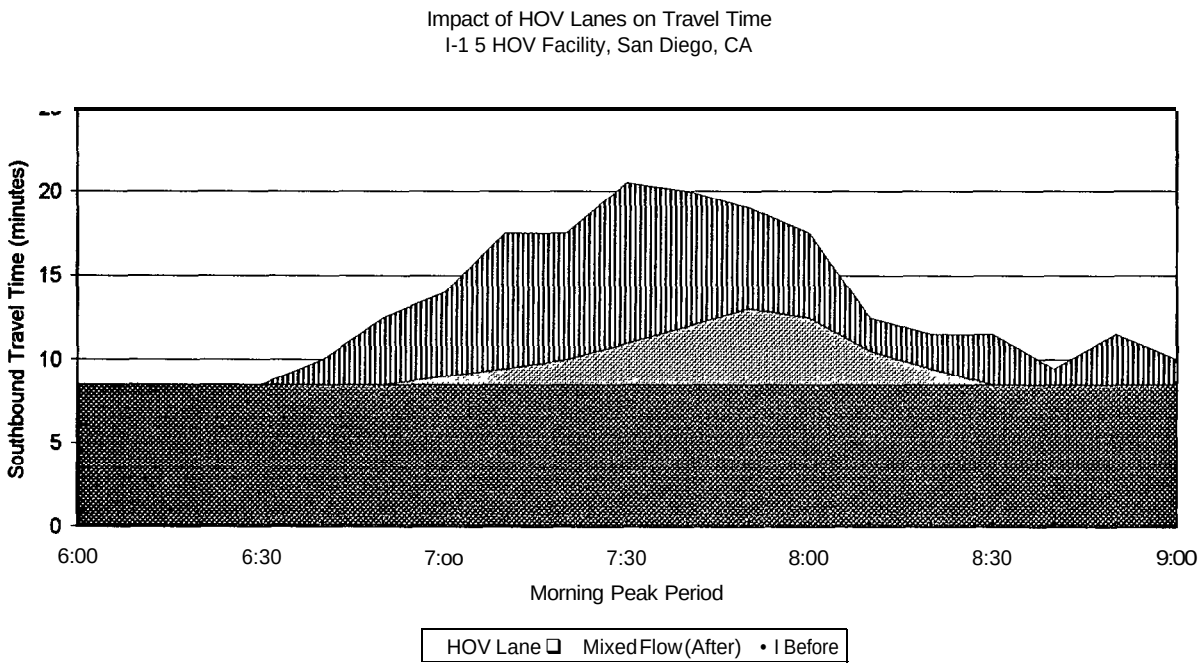

Figure D-5. Impact of HOV Lanes on Travel Time

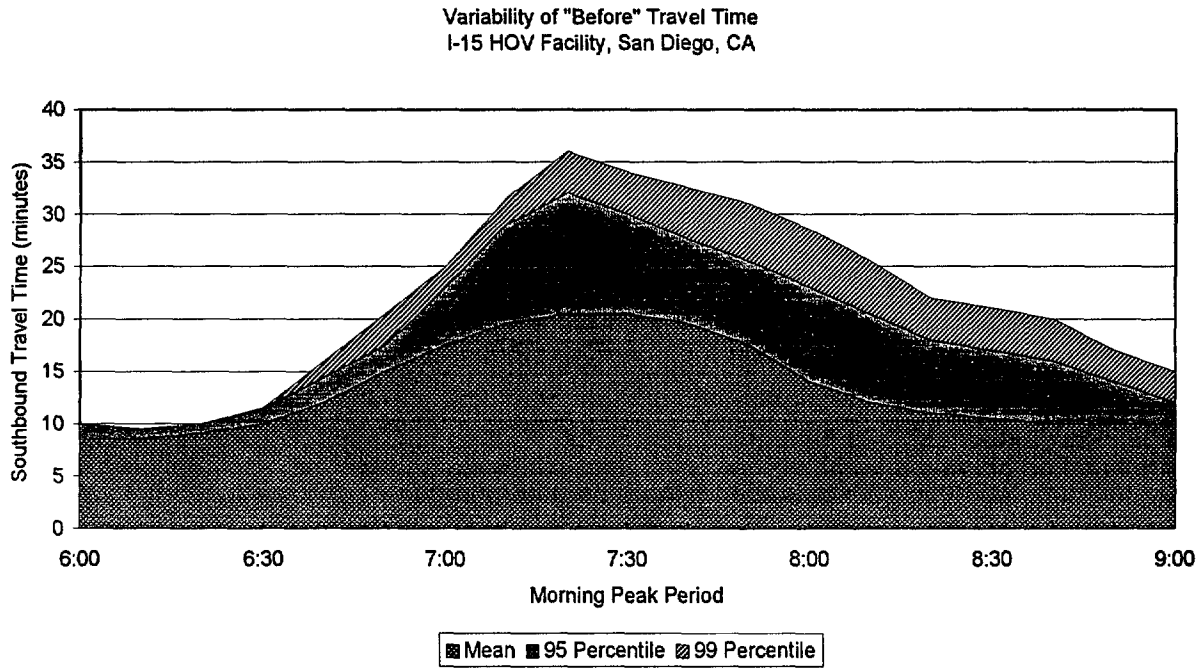

Figure D-6. Variability of "Before" Travel Time

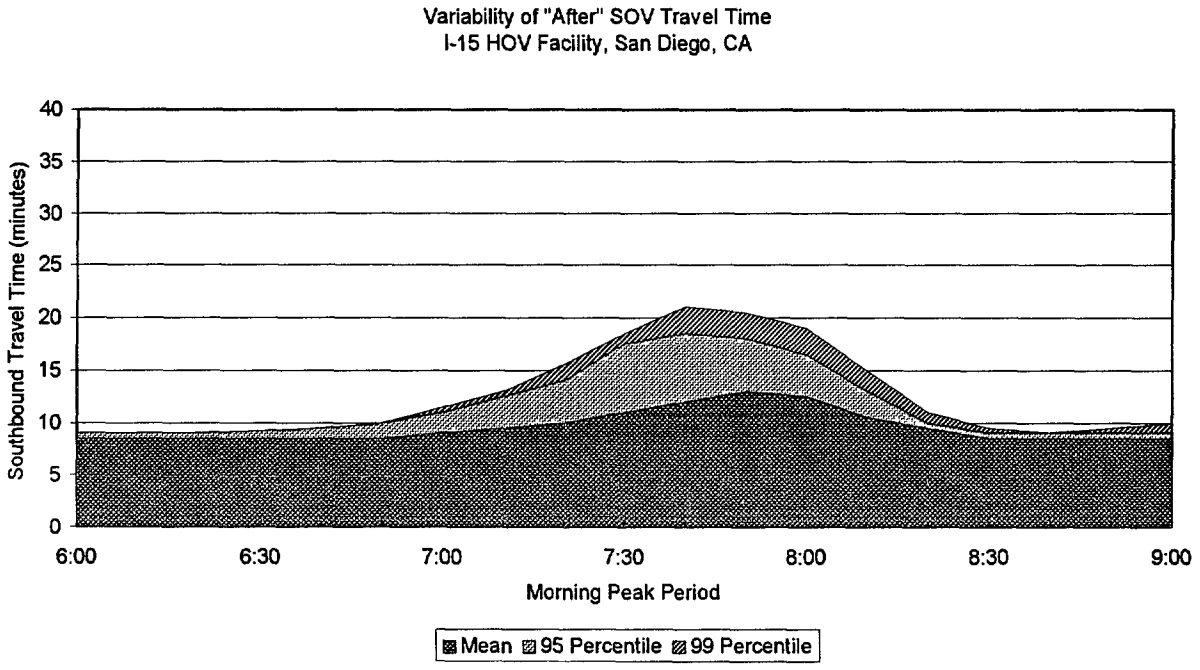

Figure D-7. Variability of "After" SOV Travel Time

Table D-15. Northwest Transitway Results

Action: Construct 9.5 mile reversible HOV lane[41]		
	Peak Hour	Peak Period
HOV Lane Volume (After)	670	820
Change in Total Vehicles[42]	+16%	13%
Change in Total Persons[43]	+26%	16%
Average Vehicle Occupancy[44]: Before: After:	 1.17 1.27	 1.17 1.19
Change in HOV Time[45]	Save 4 minutes	Save 4 minutes
Change in SOV Time[46]	Save 0 minutes (est.)	Save 0 minutes (est.)

41 Data is for morning peak period (6:00 AM to 9:30 AM), southbound direction. Before data gathered 4 months before opening, After data gathered 8 months after opening.

42 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

43 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

44 Total persons divided by total vehicles. Includes buses and vans.

45 Mean time savings for HOV lane vehicle expressed as "Before" minus "After. Estimated from 199 1 data. Rounded to nearest whole minute.

46 Mean time savings for mixed flow lane drivers expressed as "before" minus "after. Estimated from 1991 data.

D.4 CALTRANS - LOS ANGELES AND SAN D/EGO

Caltrans District 7, 12, and 11 are responsible for HOV facilities on state highways in Los Angeles County, Orange County, and San Diego County, respectively.

Caltrans District 7 has been operating HOV lanes since 1973 and currently operates 5 HOV facilities in Los Angeles area. The HOV facilities range from barrier separated lanes to concurrent freeway lanes. The facilities require 2 or more persons to be eligible for the HOV lanes. All facilities operate 24 hours for 7 days a week. Virtually all ramps in the Los Angeles metropolitan area have been metered.

Table D-16, Table D-17, and Table D-18 summarize the HOV facility characteristics for Districts 7, 11, and 12.

A rider match service program is provided by consultants or Orange County Transportation Association (OCTA).

The HOV Operations Branches of Districts 7, 11, and 12 are responsible for data collection. Vehicle counts and vehicle occupancy rates are available for both HOV lanes and mixed flow traffic.

Before/after study reports are available for I-2 10 and SR-9 1 HOV facilities. Unpublished before/after data is available for the I-210, I-405, Rte. 55, and Rte. 91. Additional before/after data is available for the I-10 Santa Monica and the I-10 El Monte facilities. No "before" data for I-105 (Century Freeway) exists since the facility opened with HOV lanes already in place.

An extensive before and after analysis was conducted by District 11 of the I-15 HOV facility in the San Diego Metropolitan Area. Several reports have been published on this facility.

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Table D-16. Caltrans District 7 - Freeway HOV Facilities

Characteristics	Caltrans District 7				
Corridor	I-10 El Monte	I-405 LA	SR91 LA	I-105 LA	I-210 LA
Begin and End	Alameda to Baldwin	Bellflower to SR605 (SB); SR110 to Century	SR110 to SR605	Century Fwy to SR605	Rte 134 to Sunflower
# of Directional HOV lanes	2	2	2	2	2
Length (lane-mi.)	23	24.6	18.9	33.2	37.0
Date Operational	73	93	85/93	93	93
HOV Eligibility	3+	2+	2+	2+	2+
Hours of HOV Operation	24 hours (7-day)	24 hours (7-day)	24 hours (7-day)	24 hours (7-day)	24 hours (7-day)
Type of facility	barrier/pylon separated two-way	striped concurrent each dir.	striped concurrent each dir.	barrier separated two-way	striped concurrent each dir.

Table D-17. Caltrans District 11 Freeway HOV Facility Characteristics

Characteristics	Caltrans District 11			
Corridor	I-15	SR 163	SR 75	I-5
Begin and End	SR 163 to North City Parkway	"A" Street to I-5	Coronado Bridge Toll Plaza	U.S. Port of Entry from Mexico
# of Directional HOV lanes	2	1	1	4
Length (lane-mi.)	19.6	0.4	0.1	0.1
Date Operational	October 1988	December 1975	?	June 1991
HOV Eligibility	2+	Buses Only	2+	4+
Hours of HOV Operation	6-9 AM (S/B) 3-6 PM (N/B)	24 hours (7-day)	24 hours (7-day)	24 hours (Mon-Fri)
Type of facility	reversible, barrier separated	striped concurrent, one direction	striped concurrent, one direction	striped concurrent, one direction

Table D-18. Caltrans District 12 Freeway HOV Facility Characteristics

Characteristics	Caltrans District 12			
Corridor	Rte. 55	I-405	I-5	Rte. 57
Begin and End	Costa Mesa to Rte. 91	I-5 to LA Co.	I-405 to Rte. 55	I-5 to LA Co.
# of Directional HOV lanes	2	2	2	2
Length (lane-mi.)	24.6	48.0	18.0	23.8
Date Operational	November 1985	April 1990	October 1992	June 1992
HOV Eligibility	2+	2+	2+	2+
Hours of HOV Operation	24 hours	24 hours	24 hours	24 hours
Type of facility	left side concurrent, buffer separated	left side concurrent, buffer separated	left side concurrent, buffer separated	left side concurrent, buffer separated

Note: All facilities are left side unless otherwise noted.

Sources:

Charles Fuhs Inventory of Current and Proposed High-Occupancy Vehicle Projects in the U.S. and Canada, January 1995.

Caltrans, California Existing, HOV Lanes, May 26, 1994.

D.4.1 I-15 HOV Facility - San Diego, California

The I-l 5 HOV Facility in the San Diego Metropolitan Area is $3 1.5 million, eight mile long pair of reversible lanes constructed in the median of the I-15 freeway. The project was opened to traffic in October 1988.

The facility is accessible only at each end. There are 5 interchanges between the starting and end points of the facility that cannot access the HOV facility.

The lanes operate in the southbound direction during the morning commute between the hours of 6 AM and 9 AM. They operate in the northbound direction between 3 PM and 6 PM. Carpools (2+ persons) vanpools, buses and motorcycles are allowed to use the facility during these hours. The facility is closed during the remainder of the day.

Project History

No changes have been made in length or operating hours since the facility's opening. Ramp metering was not present at the time of the before/after studies, but ramp metering has since been installed.

Selection of Before/After Data Set

The opening of the facility was selected for the methodology development database.

Data Collection

Al1 date was obtained from the California State University reports written by Dr. Janusz C. Supemak.

Data Reduction

Description: This data set shows the impacts of constructing an 8.0 mile (12.9 km) median, reversible pair of HOV lanes (with 2+ carpools and buses allowed). The HOV facility consists of 2 reversible lanes located in the median of an eight lane (4 lanes each direction) freeway. The average speed of the mixed flow lanes, over the length of the section, can drop to as low as 24 mph during the peak period.

The HOV facility opened October 20, 1988. Access to the HOV lane is limited to its starting and endpoints.

Travel Time Data: Before and after travel time is reported by 10 minute interval for the AM peak period. No corrections were required.

Figure D-5 shows the impact of adding an HOV lane on the peak period travel times for the mixed flow lanes. There is a significant reduction in both average delay and peak delay.

Figure D-6, and Figure D-7 show how adding an HOV lane not only reduces the average travel time and peak travel time on mixed flow lanes on a given day, but also significantly reduces the likelihood of larger delays over several days. The 99 percentile travel times (99% of the floating car runs over several days are below the 99 percentile value) for mixed flow lanes drops significantly after the addition of the HOV lane.

Volume Counts: Before and after AM peak hour eastbound counts were obtained for May 1988 and May 1989 respectively. Later data for 1990 is also available but not reported here.

Volume counts were obtained for HOV's and SOV's for both the HOV lanes and for the mixed flow lanes. These counts however did not break down the volumes by occupancy nor by vehicle type (motorcycle, truck, bus, etc.). AM peak period traffic counts classified by occupancy and vehicle type are provided in an appendix for the mixed flow lanes, but not the HOV lanes.

D.4.2 I-210 Pasadena

The I-210 Foothill Freeway HOV facility is an 18.5 mile long (29.6 km) pair of left side concurrent flow HOV lanes between State Route 134 in Pasadena and Sunflower Avenue in Glendora.

Project History

The project opened in stages between November 1993 and January 1994. Ramp metering was present before and after the project opening.

Data Collection

Before/After dam for this facility was obtained from CaItrans District 7 offices and Systan files. The before study was conducted in July 29, 1993, approximately 5 months before the project was completed and fully opened. The after study was conducted in July 19, 1994, about 7 months after the project was fully opened. Data is available only for the peak hour.

Data Reduction

Description The data set shows the impacts of constructing 18.5 miles (29.6 km) of HOV lanes in each direction. The HOV lanes are located on the left side in each direction and are separated from the mixed flow lanes by a 2 to 3 foot (60 to 90 cm) striped buffer.

Travel Time Data: The data shows a significant reduction in travel times for both the HOV lanes and the mixed flow lanes.

Volume Counts: Vehicle and passenger volumes are reported by vehicle occupancy (SOV, 2, and 3+) and for motorcycles. Count data is not reported separately for buses, vans, trucks. Motorcycle volumes were not reported for the before condition. The breakdown between 3 person HOV and 4+ HOV was estimated based upon the number of persons reported for 3+ HOV's.

D.4.3 Route 91 Los Angeles

The Route 91 Artesia Freeway HOV facility is an 10.5 mile long (16.8 km) left side concurrent flow HOV lane in the westbound direction between I-l 10 in Gardena and I-605 in Bellflower., and an 8 miles (12.8 km) long eastbound concurrent flow lane between Central Avenue in Compton and I-605 in Bellflower.

Project History

The eastbound lane opened in June 10, 1985. The westbound lane opened in March 1, 1993. Ramp metering was present before and after the project opening.

Data Collection

Before/After data for this facility was obtained from Caltrans District 7 offices and Systan files.

The before study for the eastbound lane was conducted in April 1985, approximately 2 months before the project was opened. The after study was conducted in April 1986, about 10 months after the project was opened. Data is available only for the peak hour.

Data Reduction

Description: The data set shows the impacts of two separate actions: the construction of an 8 mile (12.8 km) long HOV lane in the eastbound direction, and a 10.5 mile (16.8 km) long HOV lane in the westbound direction eight

Table D-19. I-15 San Diego HOV Results

Action: Construct 8.0 mile reversible pair of HOV lanes[47]		
	Peak Hour	**Peak Period**
HOV Lane Volume (After)	**2448**	**4786**
Change in Total Vehicles[48]	**+38%**	**+11%**
Change in Total Persons[49]	**+41%**	**+19%**
Average Vehicle Occupancy[50]:		
Before:	1.31	1.22
After:	1.34	1.31
Change in HOV Time[51]	Save 10 minutes	Save 6 minutes
Change in SOV Time[52]	Save 7 minutes	Save 4 minutes

[47] Data is for morning peak period (6:00 AM to 9:00 AM), southbound direction. Before data gathered 5 months before opening, After data gathered 7 months after opening.

48 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

49 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

[50] Total persons divided by total vehicles. Includes buses and vans.

[51] Mean time savings for HOV lane expressed as "Before" minus "After. Rounded to nearest whole minute.

[52] Mean time savings for mixed flow lane drivers expressed as "before" minus "after.

years later. The HOV lanes are located on the left side in each direction and are separated from the mixed flow lanes by a 2 foot (60 cm) striped buffer.

Travel Time Data: The data shows a significant reduction in travel times for both the HOV lanes and the mixed flow lanes.

Volume Counts: The westbound vehicle and passenger volumes are reported by vehicle occupancy (SOV, 2, and 3+) and for motorcycles. Bus and 4+ HOV count data is reported for the HOV lane but not the mixed flow lanes, and not for the 'before" condition. Count data is not reported separately for trucks. Motorcycle volumes were not reported for the before condition. The breakdown between 3 person HOV and 4+ HOV for the before condition was estimated based upon the number of persons reported for 3+ HOV's.

The eastbound count data is reported only for SOV's and HOV's. there is no further subcategorization of the HOV's by occupancy type. Truck, bus, and motorcycle volumes were not reported.

D.4.4 Route 55 Orange County

The -210 Foothill Freeway HOV facility is an 18.5 mile long (29.6 km) pair of left side concurrent flow HOV lanes between State Route 134 in Pasadena and Sunflower Avenue in Glendora.

Project History

The project opened in stages between November 1993 and January 1994. Ramp metering was present before and after the project opening.

Data Collection

Before/After data for this facility was obtained from Caltrans District 7 offices and Systan files. The before study was conducted in July 29, 1993, approximately 5 months before the project was completed and fully opened. The after study was conducted in July 19, 1994, about 7 months after the project was fully opened. Data is available only for the peak hour.

Data Reduction

Description The data set shows the impacts of constructing 18.5 miles (29.6 km) of HOV lanes in each direction. The HOV lanes arc located on the left side in each direction and are separated from the mixed flow lanes by a 2 to 3 foot striped buffer.

Travel Time Data: The data shows a significant reduction in travel times for both the HOV lanes and the mixed flow lanes.

Volume Counts: Vehicle and passenger volumes are reported by vehicle occupancy (SOV, 2, and 3+) and for motorcycles. Count data is not reported separately for buses, vans, trucks. Motorcycle volumes were not reported for the before condition. The breakdown between 3 person HOV and 4+ HOV was estimated based upon the number of persons reported for 3+ HOV's.

D.4.5 I-10 Santa Monica

The I-10 Santa Monica Freeway HOV facility was a 12.0 mile long (19.2 km) pair of concurrent flow HOV lanes formed by converting two existing mixed flow lanes (one in each direction) in the City of Los Angeles. This project is not listed in the table of Caltrans District 7 HOV projects because it is no longer active.

Project History

The project opened March 15, 1976. The increased congestion caused by the lane conversion was very controversial and resulted in the reconversion of the HOV lanes back to mixed flow use about a year after the original conversion. Ramp metering was present before and after the project opening.

Data Collection

Before/After data for this facility was obtained from Caltrans District 7 offices and Systan files. The before study was conducted October 1975, approximately 5 months before the project opened. The after study data was collected over a three month period between June and August 1976. Data is available only for the peak period.

Data Reduction

Description The data set shows the impacts of converting one mixed flow lane in each direction to an HOV lane.

Travel Time Data: The data shows an increase in travel times for SOV's and a decrease for HOVs.

Volume Counts: Vehicle and passenger volumes are reported by vehicle occupancy only for SOV+2HOV, 3+ HOV and bus. Count data is not reported separately for vans, and trucks. The breakdown between 1 person, 2 person, 3 person and 4+ person vehicles was estimated based upon the number of persons reported for 3+ HOV's and "non-3+ HOV's".

D.4.6 I-10 El Monte

The I-10 San Bernardino Freeway (El Monte Busway) HOV facility is an 11 mile long (17.6 km) partially separated HOV/Busway facility between I-605 and Downtown Los Angeles.

Project History

The project opened originally as a busway Three plus HOV's were allowed to use the busway in October 1976. Ramp metering was present before and after the project opening.

Data Collection

Before/After data for this facility was obtained from Caltrans District 7 offices and Systan files. The before study was conducted in October 1976, the same month the facility was opened to Carpools. The after study was conducted in November 1, 1977, about 13 months after the project was opened to Carpools. Data is available only for the peak period.

Data Reduction

Description: The data set shows the impacts of opening a 11 mile (17.6 km) long busway to Carpools.

Travel Time Data: The data shows a reduction in travel times for HOV's and a slight increase in travel times for the mixed flow lanes that may be due to general increase in mixed flow volumes over the year.

Volume Counts: Vehicle and passenger volumes are reported by vehicle occupancy (SOV, 2, and 3+) and for buses. Count data is not reported separately for motorcycles, vans, trucks. The breakdown between 3 person HOV and 4+ HOV was estimated based upon the number of persons reported for 3+ HOV's.

D.5 WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

The Washington State Department of Transportation currently operates 62 lane-miles (100 lane-km) of HOV lanes on three interstate highways and six state routes in the Seattle metropolitan area. The HOV system in the Seattle area is shown in Figure D-8. Seattle also has HOV lanes on a few arterial streets and HOV bypass lanes at some metered freeway ramps.

The HOV lanes are part of a larger HOV system including park-and-ride lots, transit centers, transit service improvements, rideshare programs, and TDM programs. The Washington State Department of Transportation has a policy for the freeway HOV system of improving the capability of freeway corridors to move more people by increasing the number of persons per vehicle, providing travel time savings and reliability for HOV's, and providing safe travel options for HOV's and mixed-flow traffic.

Most of the HOV lanes in the Seattle area are concurrent flow facilities allowing continuous access and egress that operate on a 24-hour basis. The HOV lanes, which may use the inside lane, outside lane, or shoulder, are delineated from the general purpose lanes by a painted line, pavement markings and signing. The occupancy requirement varies between 2 + and 3 + occupants per vehicle. WSDOT operates queue bypass facilities on SR 509 from SW Cloverdale to the 1st Avenue South Bridge and on SR 526 for buses.

WSDOT currently operates HOV lanes on the I-5, I-405, I-90, and SR 522 freeways. Additional HOV lanes are operated by WSDOT and/or the City of Seattle on SR 167 NB, SR 99 NB, SR 520 WB, and SR 509 NB (See Table D-20).

Starting in July 1991, WSDOT has been monitoring HOV lane operations in the Seattle area. The report, HOV Monitoring and Evaluation Tool: Final Technical Report, established the method for collecting data for monitoring and evaluating the impact of the HOV lanes in the Seattle area, To establish a baseline from which to evaluate impacts, vehicle occupancy data and travel time data are collected by observers positioned at various mainline and ramp locations throughout the HOV system. Data is collected for both the HOV and the general purpose lanes. Surveys were sent to vehicle owners who drive the HOV corridors to measure public perception. Additional data sources include the WSDOT accident data bank, METRO's HERO program for voluntarily reporting HOV violations, and transit ridership data.

Since many HOV lanes were in operation prior to the start of this study, "before" data is not available for many of the HOV lanes in the Seattle area. To insure that data is available in the future, the objective of the HOV Evaluation and Monitoring program is to provide baseline data for analyzing HOV lane performance and development in the Puget Sound region. This study collected data before opening of the extension of the I-5 HOV lane from Mercer St. to Yesler in 1993 and after the facility was opened several months. "Before" data was also collected for the conversion of the general purpose westbound lane on I-90 to an HOV lane.

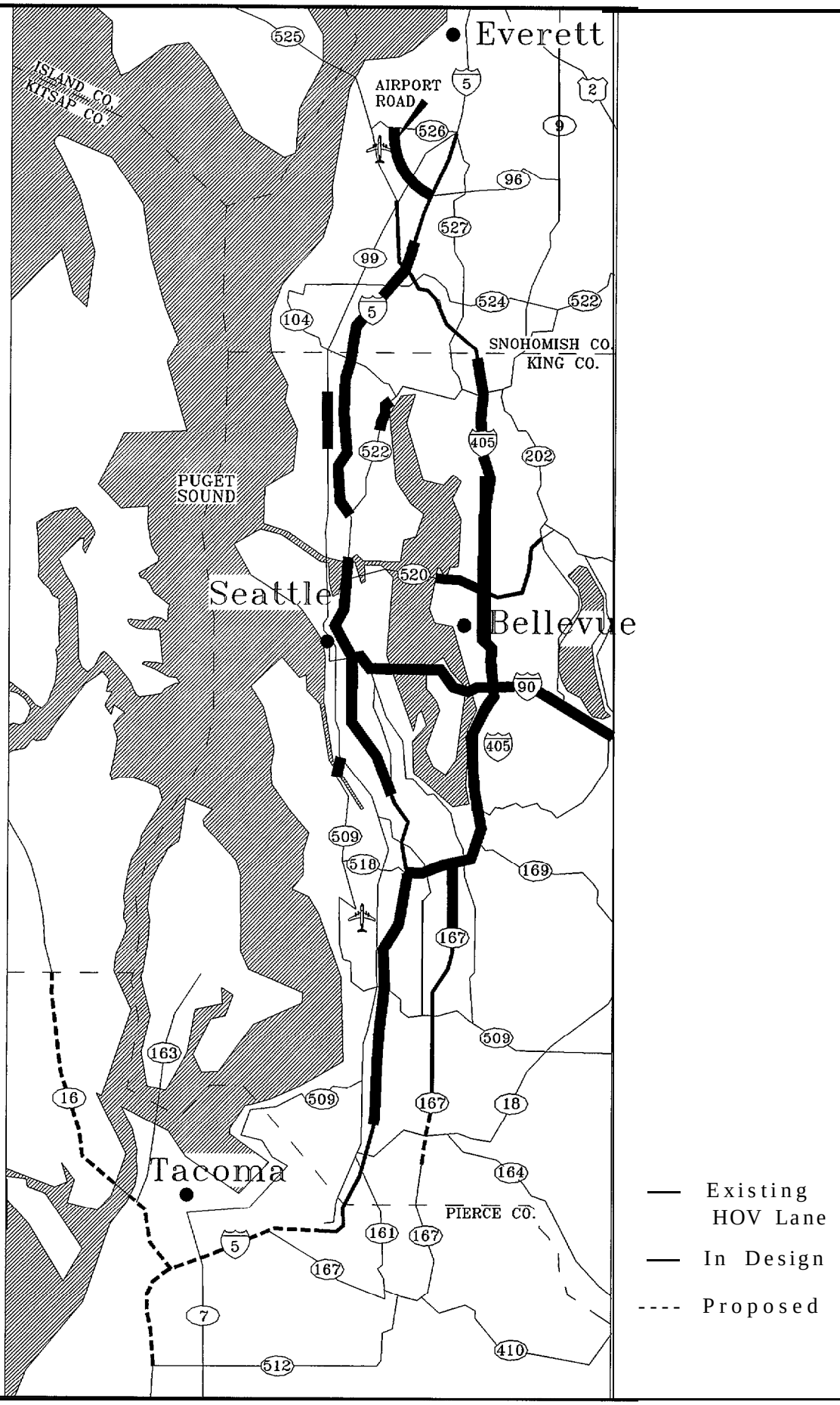

Figure D-8
HOV Facilities in the Seattle Area

Several existing HOV corridors in the Puget Sound region were identified and segmented for the initial study. Other HOV corridors will be added as the HOV lane system continues to develop. The following corridors are under observation at this stage of monitoring:

- I-5 North from Northgate to the King/Snohomish County line at SW. 236th Street,
- I-5 Downtown form Downtown Seattle at Lakeview Boulevard E. to S. 144th Street,
- I-5 South from the Southcenter Hill at S. 178th Street to S. 272nd Street,
- I-90 from the Mount Baker Tunnel at 23rd Ave S. to Bellevue Way,
- I-405 from Southcenter at Tukwila Parkway north to Kirkland/Redmond at SR 908, and
- SR 520 from Medina at Hunt's Point to Bellevue/Kirkland at SR 908.
- Also, additional outlying sites.

Data was collected from July 1, 1992 through July 5, 1993. After August 1993, the decision was made to discontinue collecting travel time data, except under special circumstances. Vehicle occupancy data is to be collected on an on-going basis.

This data is compiled into a report to be published annually with quarterly updates and is made available to WSDOT and MPOs. The data includes vehicle occupancy data for 41 locations on the HOV system and travel time data collected through license plate data from 2 1 locations. The data from the public opinion survey includes demographic data, domestic conditions, commute mode, and perceived importance and effectiveness of the HOV lanes.

As the HOV system in the Puget Sound region continues to develop, Washington State DOT has moved towards system-level studies to try to better integrate HOV lanes into more efficient system operations. Each HOV lane is not studied in isolation and the synergistic effects *among* the HOV lanes and support facilities are studied.

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Table D-20. Washington State DOT HOW Facilities

Characteristics	Washington State DOT HOV System								
Corridor	I-90 (central)	I-5 (central)	I-90 (west)	I-5 (north)	I-90 (east)	I-5 (south)	I-405	SR 167	SR 520
Limits	Rainier Ave. to East Mercer Island	Lake City Way to express lane entrance NB, Roanake to Cherry SB	5th Ave to Rainier Ave	Exp. Ln Entrance to 236th St. SW	East Mercer Island to Issaquah	Federal Way to Tukwila	Tukwila Pkwy (I-5) to NE 160th St.	North Kent to I-405	108th NE to 76th
# of HOV lanes	2	2	1 WB 1 EB	2	1 WB 1 EB	2	2	2	1 WB
Length	6.2	2.6 SB/1.6 NB	1.5	7.4 SB/4.3 NB	7.3 WB 7.1 EB	4 SB 10 NB	8.1 SB/8.6 NB	2	2.3
Date Operational	1992	70/85/87	2/92	83/91/93	1973/1994	1991/1994	1986/90/94	1988/1994	1973
HOV Eligibility	2+	2+	2+	2+	2+	2+	2+	2+	3+
Hours of HOV Operation	24 hours	5 to 11 am SB 12 to 4 pm NB	24 hours	24 hours	24 hours	24 hours	24 hours	24 hours	24 hours
Type of facility	barrier separated reversible	barrier separated reversible Express Lanes with mixed-flow	barrier separated two-way	concurrent	concurrent GP lane conversion	concurrent	concurrent, part rightside	concurrent	concurrent shoulder
Ramp Metering	50 at various locations								
Park-and-ride facilities	49 permanent (major) lots and 41 leased lots. Total capacity is 16,300 spaces								
Other support facilities	Direct access ramps		connects to bus tunnel						
Bus Service	Yes	Yes	Yes	Yes	Yes				

All HOV lanes are on the left side unless otherwise noted.

Sources:

Jacobson, Eldon L., 1995.

Turnbull, Katherine. An Assessment of High-Occupancy Vehicle Facilities in North America: Executive Report, Texas Transportation Institute, August 1992, Table 1. General Characteristics of Operating HOV Facilities.

Fuhs, Charles. Inventory of Existing and Proposed High-Occupancy Vehicle Projects, June 1994.

D.5.1 Traveler Surveys

Several surveys on travel behavior have been conducted in the Seattle metropolitan area. The Puget Sound Council of Governments (PSCOG), the Municipality of Metropolitan Seattle (METRO), and the Washington State Transportation Center (TRAC) have conducted surveys.

PSCOG Survey

The PSCOG Transportation Panel Survey contacted 5,152 households in the Puget Sound area through random-digit dialing from September to December of 1989. Of the households contacted, 33%, or 1,680 respondents, completed two-day travel diaries. In February and March of 1990, each respondent was sent an attitudes and values survey to measure cognitive and affective perceptions towards mode choice. The respondents were surveyed again in the fall of 1990 for travel diary information and the fall of 1991 for attitudinal data. This survey captures the dynamic aspects of mode choice since it collected data at more than one point in time. The PSCOG survey data supports the importance of the perception of modes and modal accessibility in mode choice.

METRO Surveys

METRO sponsored two studies which surveyed employees and residents in the north King County and urban Snohomish County area. The employee survey was an evaluation of Transportation Demand Management (TDM) /Transportation Systems Management (TSM) strategies of 23 businesses employing 50 or more employees who elected to participate. The survey, while biased toward white collar employees with higher than average incomes, looked at employee mode choice and the effectiveness of commuter programs. The report summarizing the results of the survey was published in December 1989.[53]

METRO's market segmentation study was conducted by Gilmore Research Group. The survey was a random-digit telephone survey of 3,586 residents of north King County and urban Snohomish County. Six times as many respondents lived in Snohomish county as compared to King county. The telephone survey included household characteristics, mode choice, trip characteristics, and attitudes toward mode choice.[54]

I-405 Survey

An operational analysis of the I-405 HOV facilities was conducted by the Washington State Transportation Center (TRAC). A public opinion survey was conducted as part of the study. The data collection included demographics, mode choice, and constraints to mode choice; attitudes about and perceptions of different modes; and attitudes about HOV lane issues and operations. The attitudes and perceptions of different modes was taken directly from the Puget Sound Council of Governments Transportation Panel Survey. The survey was administered in April and May 1990 at driver licensing offices in Bellevue, Kirkland, and Renton by TRAC and WSDOT.

This method proved to have a very high rate of response at 87%, or 1,545 of the 1,775 surveys handed out. The survey results were analyzed comparing SOV to carpool, SOV to bus riders, and carpoolers to bus riders. The findings covered such areas as mode usage, carpool characteristics, and reasons for driving alone. One interesting finding was that the majority of the Carpools comprised of co-workers and not spouses or children. The list of statistically significant variables included education, occupation, household income, average number of workers per household, and average number of household vehicles. One problem with this study is that the sample does not represent the typical commute population, but a subset of young, professionals with middle to upper middle incomes.

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53 Laurie McCutcheon *Marketing Commuter Programs: Surveys of North King County and Urban Snohomish County Employees.* Municipality of Metropolitan Seattle, December 1989.

54 Gilmore Research Group. *1989 North King County and Urban Snohomish County Transportation Market Segmentation Study, Volumes I and II.* Prepared for the Municipality of Metropolitan Seattle, August 1989.

D.5.2 I-90 - Seattle, Washington

I-90 is a six lane (3 lanes in each direction) freeway between I-405 and downtown Seattle. East of I-405, I-90 widens to eight lanes. This project converted one of the extra lanes in each direction to HOV use. Thus I-90 was converted to a six mixed-flow lane freeway from East Bellevue Way (near I-405) and Issaquah (near State Route 900) with a right-side concurrent flow HOV lane in each direction.

The project is 10 kilometers long (6.2 miles). The HOV lanes are open to 2+ carpools. There was no congestion in this section of I-90 before the conversion, and there was no congestion within the seven months after completion of the HOV lane conversion. The project was opened in November 1993. Ramp metering was not present on this section of I-90 during the before and after studies.

Selection of Before/After Data Set

The project opening was selected as the action for the methodology development database. This project is of interest precisely because there was no congestion before or after its opening. This project shows if there is an "inherent" effect of an HOV lane on HOV usage that is unrelated to time savings.

Data Collection

All data was taken from the Washington State Transportation Center's report on the I-90 lane conversion, dated February 1995. The before data set was gathered the same month in which the conversion was opened to traffic. The after data set was gathered 7 months after the project opening date.

Data Reduction

Description: This data set shows the impacts of converting 3.7 miles (6.0 km) of an existing mixed flow lane to HOV use and constructing an additional 2.5 mile (4.0 km) shoulder HOV lane. The HOV facility consists of a concurrent flow lane on each side of a six lane freeway (3 lanes plus HOV lane in each direction). The average speed over the length of the section never dropped below 53 mph during the peak period.

Travel Time Data: Travel times were computed from the reported before and after average speeds for the 3 hour morning peak period. Since the before and alter average speeds are both above 55 mph, no congestion appears to be present. Thus the maximum travel time is assumed to be equal to the average travel time for the peak period. Before and after travel times differed by 0.2 of a minute.

Volume Counts: Before and after AM peak period westbound counts were obtained for Fall 1993 and Summer 1994 respectively. Count data was reported by lane, but not by occupancy type or vehicle type. The HOV lane violation rate was reported to be 5%.

No peak hour data was reported. Table D-2 1 shows the results.

Sources:

- Soon Gwan Kim, Jodi Koehne, Fred Mannering, I-90 Lane Conversion Evaluation, Washington State Transportation Center, Seattle, Washington, February 1995.

Table D-21. I-90 HOV Results

Action: Convert 3.7 miles of mixed flow lanes to HOV lane, add 2.5 miles of HOV lane[55]		
	Peak Hour	Peak Period
HOV Lane Volume (After)		618
Change in Total Vehicles[56]	-%	-4%
Change in Total Persons[57]	-%	-4%
Average Vehicle Occupancy[58]: Before: After:		 1.12 1.12
Change in HOV Time[59]	Save 0 minutes	Save 0 minutes
Change in SOV Time[60]	Save 0 minutes	Save 0 minutes

[55] Data is for morning peak period (7:00 AM to 10:00 AM), westbound direction. Before data gathered same month of opening, After data gathered 7 months after opening

[56] Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

[57] Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

[58] Total persons divided by total vehicles. Includes buses and vans,

[59] Mean tune savings for HOV lane expressed as "Before" minus "After. Rounded to nearest whole minute.

[60] Mean time savings for mixed flow lane drivers expressed as "before" minus "after.

D.5.3 I-5 North - Seattle, Washington

The I-5 North HOV lanes are concurrent flow lanes located to the north of downtown Seattle extending 7.7 miles in the southbound direction and 7.2 miles in the northbound direction. The project limits extend from NE Northgate Way on the south to 236th Street Southwest on the north. The HOV lanes are a left-hand side, concurrent flow facility that operates for 24 hours a day. Table D-22 summarizes the characteristics of the I-5 North HOV facility.

This section of the I-5 freeway is ramp metered during the peak periods.

Project History

Ramp meters with HOV bypass lanes were first installed on this section of I-5 on September 30, 1981. Thirteen southbound and five northbound on-ramps were metered between the limits of NE 45th Street on the south and 44th Avenue on the north. HOV bypass lanes were installed at 6 of the 13 metered southbound on-ramps. An HOV bypass lane was also installed at one of the five metered northbound on-ramps. The southbound meters operate during the AM peak period (6-9 AM). The northbound meters operated during the PM peak period (3:30-6:30 PM).

The HOV lanes were installed in August 29, 1983 and opened to 3+ occupancy vehicles.

The occupancy requirement for the I-5 North HOV lanes was lowered to 2+ persons per vehicle in July 1991 as part of a demonstration project.

Selection of Before/After Data Sets

Three actions can be identified from the project history:

A. Installation of Ramp Metering with HOV Bypass Lanes.

B. Construction of HOV Lanes.

C. Conversion from 3+ to 2+ Operation.

Data Collection

Three sets different reports were used to evaluate the three actions. The "FLOW" reports by WDOT provided data on the effects of ramp metering. The "HOV" reports by WDOT provided data on the impacts of the HOV lanes. The "I-5 North HOV Lane" report by TRAC provided data on the impacts of converting from 3+ to 2+ operation.

The "FLOW' study was conducted in 1983. This report provides data on the traffic flow impacts of ramp metering for the 2 year period prior to the construction of the HOV lane on the I-5 freeway mainline. Data is provided on ramp delays, meter violations, and volumes for the AM peak period in the southbound direction. Before volumes were gathered in September 199 1. After volume counts are available for March and September 1982 and 1983. Mainline freeway travel times are shown by 15 minute period for 1981, 1982, and 1983 for both the AM (6:30-8:30 AM) and PM (4:00-6:00 PM) peak periods. Accident data is also provided.

The ramp meters reduced southbound AM peak delay on the freeway mainline from 5 minutes to 2 minutes. Freeway mainline congestion was reduced but not eliminated by the ramp meters.

Two "HOV" reports provide data for 3 months and 20 months after the opening of the I-5 HOV lanes. AM and PM peak hour vehicle and person volumes for the HOV lanes only are reported for two-weeks, three-months, and twenty-months after project opening. The percentage of vehicles by occupancy and vehicle type are also reported. Before (1982) and after (1983) freeway mainline volumes and travel times are reported by 15 minute periods for the southbound AM peak period (6:30-8:30 AM) and the northbound PM Peak period (4-6 PM). Violation and accident data are also briefly summarized.

The I-5 North demonstration project was conducted to determine how the change in vehicle occupancy requirements affects the objectives of the HOV program, specifically, person throughput, vehicle occupancies, travel time savings and reliability, and safety. The data collection activities included:

- Vehicle occupancy counts for both HOV and general purpose lanes
- Travel time surveys using license plate methodology for both HOV and general purpose lanes
- Utilization levels and lane vehicle volumes from loop detectors
- Accident data from State Patrol
- Calls for the HERO program from Seattle Metro (violations)
- Bus ridership and park-and-ride lot utilization rates from Community Transit
- Surveys of transit riders, carpoolers, and motorists conducted by Community Transit evaluating HOV lanes in the Seattle area.

The demonstration project was conducted by University of Washington with the Texas Transportation Institute. The evaluation of the demonstration project was based on meeting the objectives established by the WSDOT HOV policy. The impacts of the occupancy requirement change were assessed for the HOV lane and the general purpose lanes. Public perception was also measured through surveys of bus riders, carpoolers, and motorist.

Vehicle occupancy data was collected for the I-5 North in 1989 and 1990 as part of the WSDOT Vehicle Occupancy Monitoring Project, again in July 199 1, four days prior to the start of the demonstration, and the over the first five months of the demonstration project. All counts were made at 145th Street.

The low response rate from the survey of carpoolers and general purpose motorist did not provide statistically valid results.

Travel time data was collected using the license plate methodology rather than a floating car. License plates were recorded at 236th Street and 117th Street. The difference in PM peak hour travel time was minimal. Travel time in the HOV lane was 7.5 minutes while that in the mixed-flow lanes was 7.98 minutes.

Vehicle occupancies were measured at 145th Street. The report contains average occupancy, total person throughput, and percentages of 2 person Carpools, 3 person car-pools, and single occupant vehicles.

Counts were from loop detectors embedded in the pavement that are part of the on-going WSDOT monitoring program. AM peak hour and peak period counts were collected at 3 locations. PM Peak hour and peak period counts were collected at 2 locations.

Three different groups were surveyed. The surveys focused on the impacts of the change in occupancy and the general attitude toward HOV lanes. An on-board survey of transit riders was conducted on November 2 1, 1991 with 926 surveys (71%) completed and returned. Carpoolers and motorists had much lower response rates of 10% (57 completed surveys) and 30% (160 completed surveys). The data, though not statistically significant, showed the mode shift due to the change in occupancy. The completed carpool surveys showed the following general trends: 15 of 57 (26%) carpool were formed in the last 6 months, 12 of the 15 formerly drove alone, and 2 of the 15 previously rode the bus. The attitude toward the occupancy change was one of strong support from motorists and carpoolers, while only 39% of the bus riders favored the change.

The demonstration project showed that the occupancy requirement change negatively impacts the operation of the HOV based on the policy objectives. However, the public perception surveys supported the change overall. As a result, despite the lower performance based on the policy objectives, the WSDOT elected to maintain the lower occupancy requirement of 2+ persons per vehicle due to the strong public support for it and the fear of public opposition if returned to the 3+ requirement.

Data Reduction

Data reduction varied by action.

Action "A": Install Ramp Metering:

This data set shows the impacts of installing ramp metering on 13 out of 15 southbound on-ramps over a 6 mile section of a freeway without an HOV lane. Six of the 13 on-ramps with meters have HOV bypass lanes. The HOV facility consists of HOV bypass lanes at 6 southbound on-ramps on a six lane freeway (3 lanes in each direction). The bypass lanes are limited to 3+ carpools and are operated from 6:30 AM to 8:30 AM each weekday. (There are also 5 metered northbound ramps during the PM peak period with one ramp having an HOV bypass lane.)

Ramp metering and the HOV bypass lanes were opened on September 30, 198 1.

Travel Time Data: The maximum ramp delay for non-HOV's was reported to be 8 minutes. The average delay was reported to be 2 to 3 minutes. HOV's had no delay.

Volume Counts: Before and after AM peak period (6:00-8:30 AM) southbound on-ramp volume counts were obtained for September 198 1 and September 1982 respectively. The reported volumes do not distinguish between HOV bypass lane volumes and other lane volumes. The ramp meters and HOV bypass lanes caused a 19% net reduction in AM peak period vehicle volumes using the metered ramps (See Appendix "A" for results).

It is reported that 9% of the on-ramp volumes used the HOV bypass lanes and that one-third of the bypass lane users are violators (less than 3+ Carpools).

Sources:

- S.M. Betts, L.N. Jacobson, H.J. Mieras, T.D. Pickman, PLOW, A Two Year Evaluation, Washington State Department of Transportation, District No. 1. Traffic Systems Management Center, Seattle, Washington, December 1983.

Action "B": Construct HOV Lanes:

This data set shows the impacts of constructing a concurrent flow, left-hand side HOV lane on a freeway. The HOV facility consists 5.6 miles (9.0 km) southbound and 4.0 miles (6.4 km) northbound of concurrent flow, left-hand side HOV lanes on a six/eight lane freeway (3 or 4 lanes in each direction). Ramp metering with HOV bypass lanes (see previous project description) was already in place prior to the HOV lane construction.

The HOV lanes were opened on August 29, 1983. Ramp metering with HOV bypasses (see Action "A") were present both before and after the lane construction.

Travel Time Data: Mixed flow lane travel times were reported by 15 minute time period over the 6:30 to 8:30 AM peak period for a 11.2 mile segment of the freeway. These times were converted to equivalent times for a 5.6 mile run for the mixed flow lanes by proportioning the time for the shorter distance traveled (in effect assuming the average speed over the larger length was the same for the shorter length).

The HOV lane times were computed assuming free flow travel at 55 mph.

Volume Counts: Before and after AM peak period (6:00-8:30 AM) southbound volume counts were obtained for September 1982 and September 1983 respectively. The reported volumes are not segregated by occupancy nor vehicle type.

It is reported that 25% of the HOV lane volumes were violators (less than 3+ carpools).

The before/after results are summarized in Table D-23.

Sources:

- S.M. Betts, L.N. Jacobson, H.J. Mieras, T.D. Rickman, FLOW, A Two Year Evaluation, Washington State Department of Transportation, District No. 1, Traffic Systems Management Center, Seattle, Washington, December 1983.
- S.M. Betts, L.N. Jacobson, T.D. Rickman, HOV, High Occupancy Vehicle Lanes, Three Month Report, Washington State Department of Transportation, District No. 1, Traffic Systems Management Center, Seattle, Washington, December 1983.
- K.C. Henry, M.J. Jacobs, A Twenty Month Report, HOV, High Occupancy Vehicle Lanes, Washington State Department of Transportation, District No. 1, Traffic Systems Management Center, Seattle, Washington, May 1985.

Action "C": Conversion from 3+ to 2+:

This data set shows the impacts of converting 7.7 miles (12.4 km) of an existing, left-hand side, concurrent flow HOV lane from 3+ to 2+ carpools. The HOV facility consists of a left-hand lane, concurrent flow lane on each side of a six lane freeway (3 lanes plus HOV lane in each direction). Ramp metering with HOV bypass lanes at half the on-ramps was also in place at the time. The average speed over the length of the section never dropped below 55 mph during the peak period.

The HOV conversion occurred on July 29, 1991. Ramp metering with HOV bypasses (see Action "A") were present both before and after the conversion.

Travel Time Data: Average travel times were reported for the peak hour only. The maximum times are assumed to be the same as the mean travel times during the peak hour.

Volume Counts: Before and after AM peak hour southbound volume counts were obtained for September 1990 and September 1991 respectively for the HOV lane and the mixed flow lanes,

The volume by occupancy type (SOV,2,3+pool) was estimated based upon graphs showing the percent of before and after traffic across all lanes for the before and after condition. A 10% violation rate was assumed. The vehicles were then distributed by occupancy type and between the HOV lane and the mixed flow lanes to match the observed percentages and total volume by lane type. Motorcycle and truck volumes were estimated based upon an assumed percentage of the total volumes (This was necessary in order to achieve the total reported lane volumes).

No peak period data was reported.

The before/after study results are summarized in Table D-24.

Sources:

- Cy Ulberg, Gary Farnsworth, Graciela Etchert, Katherine Tumbull, Russell H. Henk, and David L. Schrank. I-5 North High-Occupancy Vehicle Lane 2 + Occupancy Requirement Demonstration Evaluation, Washington State Department of Transportation (TRAC) with Texas Transportation Institute (TTI), February 1992.

Table D-22. I-5 North HOV Facility

Characteristic	I-5 North HOV System
Limits	HOV Lanes: NE Northgate Way to 236th Street SW Meters: NE 45th Street to 44th Avenue West (in 1981)
# of HOV lanes	1 in each direction
# of general purpose lanes	3 in each direction
Length	7.7 miles SB 6.2 miles NB
Date Operational	1983
HOV Eligibility	3+ (changed to 2+ July 1991)
Hours of HOV Operation	24-hours
Type of facility	concurrent
Ramp Metering	yes
Park-and-ride facilities	yes
Other support facilities	Transit centers, rideshare and TDM programs
Bus Service	Service improvements

Table D-23. Action "B" I-5 Seattle Results

Action: Construct 5.6 miles HOV lanes[61]		
	Peak Hour	Peak Period
HOV Lane Volume (After)		680
Change in Total Vehicles[62]		+15%
Change in Total Persons[63]	-	-
Average Vehicle Occ.[64] Before: After:		 - -
Change in HOV Time[65]	-	Save 2 minutes
Change in SOV Time[66]	-	Save 1 minutes

Table D-24. Action "C" I-5 Seattle Results

Action: Convert from 3+ to 2+ Occupancy Requirement[67]		
	Peak Hour	Peak Period
HOV Lane Volume (After)	1,000	-
Change in Total Vehicles	+12%	-
Change in Total Persons	+16%	-
Average Vehicle Occupancy: Before: After:	 1.25 1.30	 - -
Change in HOV Time	Save 2 minutes	-
Change in SOV Time	Save 2 minutes	-

61 Data is for Morning Peak Period (6:00 AM to 8:30 AM) southbound direction. Before data gathered 12 months before opening, After data gathered 3 months after opening.

62 Total vehicles in peak direction, expressed as "After" minus "before", divided by "before".

63 Total persons in peak direction expressed as "After" minus "before", divided by "before".

64 Total persons divided by total vehicles. Includes buses and vans.

65 Mean time savings for HOV lane: "Before" minus "After. Rounded to nearest whole minute.

66 Mean time savings for mixed flow lane drivers expressed as "before" minus "after.

67 Data is for morning peak period (6:00 AM to 9:00 AM), southbound direction. Before data gathered 11 months before opening, After data gathered 2 months after opening.

D.6 CALTRANS - DISTRICT 4 - SAN FRANCISCO

Caltrans District 4 has been operating HOV lanes since 1970. There are currently 20 HOV facilities in operation totaling 158 lane-miles (254 lane-km) of freeway and expressway lanes in the San Francisco Bay Area. An additional 10 projects totaling 178 miles (286 km) are anticipated to be opened by the year 2000. These facilities are shown in Figure D-9. The types of facilities range from concurrent freeway lanes to toll bypass lanes on the bridge toll approaches. Caltrans also operates one HOV facility on an arterial street that is part of the state highway system. In general, the facilities require 2 or more persons to be eligible for the HOV lanes, with the exception of several bridge toll bypass facilities. Hours of operation differ depending upon the peak period of the facility. Table D-25 and Table D-26 summarize the HOV facility characteristics for Caltrans District 4.

The Highway Operations Branch of District 4 is responsible for the data collection on all of the HOV facilities under its jurisdiction. HOV facility operations data is summarized annually in the "Annual HOVL Report." The report published by Caltrans District 4 covers all HOV lanes under their jurisdiction since 1988. The report includes the peak period and peak hour vehicle and person volumes for the HOV lane and the adjacent mixed-flow lanes, the vehicle occupancy rates, the violation rates, and travel times. The report also contains some general information on the HOV facilities such as the date opened, the HOV lane eligibility, the hours of operation, the length of facility, and the milepost location. This report provides annual facility data for the HOV lanes in the Bay Area.

The data for HOV lanes are collected twice a year by observers during peak hours. To ensure that the data collected represents a "typical" non-incident weekday, the data collection is canceled and rescheduled if an incident occurs during the data collection. Each travel lane is monitored by an individual observer who records the vehicle occupancy count in 15-minute intervals. The HOV facility data includes the vehicle counts for both HOV lane and adjacent general-purpose lanes in 15-minute intervals from loop detectors, person counts by individual vehicle in 15-minute intervals, and travel speeds from floating car surveys. The most recent two years of data are saved in a Macintosh-based Excel format. Earlier data are available in hardcopy from the district offices.

Four "before-and-after" reports are available for selected routes. The reports are for US 101 (2 segments), I-280, and SR 237. The "before-and-after" reports summarize the evaluation of traffic volumes, vehicle occupancy rates, travel time savings, and travel speed for before-and-after conditions. The after condition covers the first year of operation for the HOV facility. Additional "before-and-after" raw data are available, but have not been analyzed or published in report format.

D.6.l San Francisco Bay Area HOV/SOV Driver Surveys

Two major HOV/SOV driver surveys have been conducted in the San Francisco Bay Area. One was conducted in 1990 at six HOV locations throughout the Bay Area. The other was conducted in 1995 also at six HOV lane locations (two of these locations the same as for the previous study).

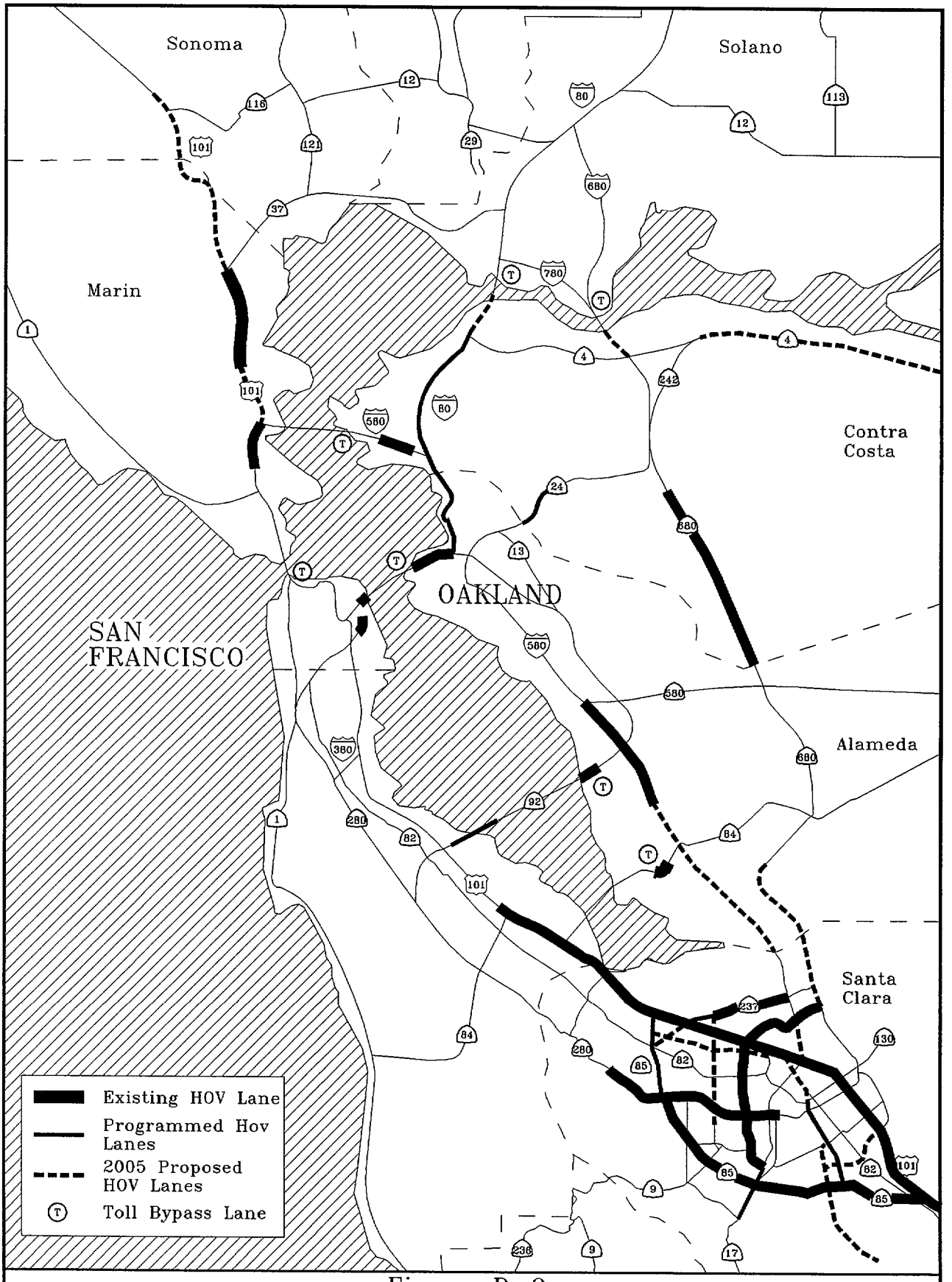

Figure D-9
HOV Facilities Operated by Caltrans and Santa Clara County in the San Francisco Bay Area

94044 FIGD-9.DWG 5-28-96

Table D-25. Caltrans District 4 HOV Facilities

Characteristics	Caltrans District 4									
Corridor	US 101 Marin	US 101 Marin	US 101 SCL/SM	US 101 SCL	I-880	I-280	I-680	I-580	SR 237	SR 85
Begin and End	Richardson to Greenbrae	N. San Pedro to Rte 37	Whipple to Guadalupe	Guadalupe to Bernal	Rte238 to Whipple	Magdalena to Leland	I-580 to Rudgear	Marine to Central	I-880 to Mathilda	SR237 to I-101 Gilroy
# of Directional HOV lanes	2	2	2	2	2	2	2	2	2	2
Length (mi.)	3.7	6.1	18.5	13.2	7.3	11.2	10.4	5.1	6	22.2
Date Operational	74	86/87	86/91	90/93	91	90	94	89	84	90/94
HOV Eligibility	bus only to 2+	2+	2+	2+	2+	2+	2+	2+	2+	2+
Hours of HOV Operation (weekdays only)	6:30-8:30am SB 4:30-7pm NB	6:30-8:30am SB 4:30-7pm NB	5-9am 3-7pm	5-9am 3-7pm	5-9am 3-7pm	5-9am 3-7pm	6-9am 3-6pm	7-8am 5-6pm	5-9am WB 3-7pm EB	5-9am 3-7pm
Type of facility (barrier sep. 2-way, reversible flow, concurrent, etc.)	striped concurrent each dir.	striped concurrent each dir.	striped concurrent each dir.	striped concurrent each dir.	striped concurrent each dir.	striped concurrent each dir.	striped concurrent each dir.	striped concurrent each dir.	striped concurrent each dir. arterial (right lane)	striped concurrent each dir.
Ramp Metering (# of location, HOV bypass)	None	None	Yes	6 NB locations	None	1 NB and 3 SB locations	None	None	None	8 NB and 4 SB locations

All HOV lanes are on the left side unless otherwise noted.

Source: Caltrans - District 4. Annual HOVL Report, December 1994.

Table D-26. Caltrans 04 Bridge Toll and Ramp HOV Bypass Facilities

Characteristics	Caltrans District 4									
Type of HOV Facility	HOV Toll Plaza							Ramp HOV Bypass		
Corridor	I-80	SR84	SR92	I-80	SR160	I-580	I-680	SR85 SCL	US101 SCL	I-280 SCL
Name of Bridge /Ramp Locations	Bay Bridge	Dumbarton Bridge	San Mateo Bridge	Carquinez Bridge	Antioch Bridge	San Rafael Bridge	Martinez Bridge	SCL Co.	SCL Co.	SCL Co.
# of Directional HOV lanes or # of Ramp Locations	4 WB only	1 WB only	1 WB only	1 EB only	1 NB only	1 WB only	1 NB only	12 locations NB(8) & SB(4)	6 locations for NB	4 locations NB(1) & SB(3)
Length (mi.)	3.9	1.8	2	approach only	approach only	approach only	approach only	N/A	N/A	N/A
Date Operational	70	82/89	89	91	91	89	91	94	80/82/91/92	77/80/93
HOV Eligibility	3+	2+	2+	3+	3+	3+	3+	2+	2+	2+
Hours of HOV Operation (weekdays only)	5-10am WB 3-6pm WB	5-10am WB 3-6pm WB	5-10am WB 3-6pm WB	5-10am EB 3-7pm EB	5-10am NB 3-7pm NB	5-10am WB 3-6pm WB	5-10am NB 3-7pm NB	24 hours	varies by locations	varies by locations
Type of facility2 (barrier sep. 2-way, reversible flow, concurrent, etc.)	concurrent pylon separated in WB only.	striped concurrent in WB only.	striped concurrent in WB only.	striped concurrent in EB only.	striped concurrent in NB only.	striped concurrent WB only.	striped concurrent in NB only.	striped concurrent on-ramp lane.	striped concurrent on-ramp lane.	striped concurrent on-ramp lane.

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Fax: (510) 286-4561

Sources:

Caltrans - District 4, Highway Operations Branch, Annual HOVL Report - Overall Volumes and HOVL Violation History, reports available from 1990 to 1994.

1990 HOV Survey

The "San Francisco Bay Area HOV Lane User Study"[68] describes the survey of HOV drivers identified from videotapes at eight locations on six HOV lanes throughout the Bay Area. HOV lanes were videotaped at the following locations:

- San Tomas Expressway
- Bay Bridge Toll Approach WB
- Sterling on-ramp to Bay Bridge EB
- US 101 Santa Clara SB
- US 101 Santa Clara NB
- Dumbarton Bridge Toll Approach WB
- US 101 Marin - Corte Madera
- US 101 Marin - San Rafael

The 11,401 license plates videotaped and identified yielded 998 completed surveys. The surveys were administered over the telephone in late 1989 and early 1990. The purpose of the survey was to measure carpool attitudes and identify factors that influence Carpool formation. Due to the Loma Prieta earthquake, the survey included pre- and post-earthquake travel patterns in addition to the originally planned questions on carpool formation, demographics, and HOV lane perceptions and attitudes.

The key survey results were as follows:

- The average trip length for carpools was 25 miles.
- Drivers perceived travel time savings to be more than double the average savings recorded during the peak hour and four times that recorded during the peak period.
- Casual car-pooling amounted to about 36% of the Carpools on the Bay Bridge.
- More than half (54%) of the car-pools were formed through household members. Another 29% were formed with co-workers.
- About 22% of carpoolers pay for parking. The average cost for parking (among those paying) was $118 per month.
- Transit was found to be a significant source of carpoolers only on the Bay Bridge and US 10 1 in Corte Madera.

68 John W. Billheimer. San Francisco Bay Area HOV Lane User Studs. Final Report, June 1990

1995 HOV Survey

The 1995 survey[69] was conducted at six HOV lane facilities:

U.S. 101, Marin County;

I-680, Contra Costa County;

I-880, Alameda County;

State Route 237, Santa Clara County;

U.S. 101, Santa Clara County; and

I-280, Santa Clara County.

The same video-taping and postcard mailout survey procedure was used as in the 1990 survey. A total of 77,925 vehicles were videotaped in the six corridors during the morning peak period. Eighteen percent of these vehicles were eliminated from the sample because they were trucks, commercial vehicles, out-of-state vehicles, or had unreadable license plates. Another 6% of the total sample was eliminated due to invalid plates or out of area residences for the vehicle owners. Survey forms were sent to 59,473 vehicle owners. Completed surveys were received from 28% (16,855) of the total mailed out.

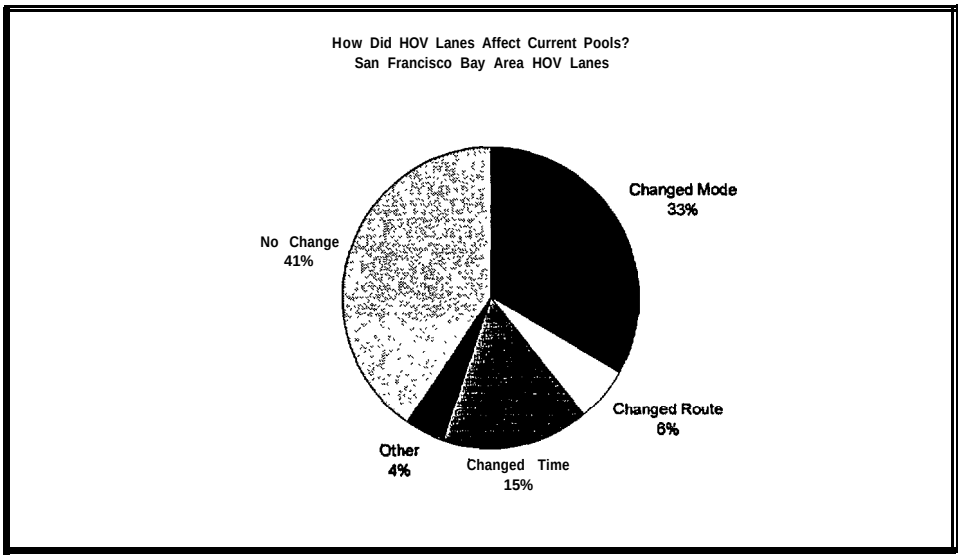
The salient results of the survey are as follows (Note that only vehicle owners were surveyed. The results do not necessarily account for vehicle drivers or vehicle passengers):

- Home to Work trips accounted for 86% of the morning peak trips in the sample. Business related trips accounted for an additional 4% of the sample. School commute trips accounted for another 3%.
- Carpoolers (2+ persons) accounted for 13% of the vehicles traveling in the study corridors during the morning peak period.
- The average trip length is 28 miles for carpoolers, 27 miles for non-carpoolers.
- 56% of Carpools were formed with other household members. 3 1% of the carpoolers pool with co-workers.
- The average pool driver/vehicle owner has been pooling 3 years. This is not the same as average duration of a given pool.
- HOV lanes that had been in place for longer than 5 years were cited by 34% of poolers as being a primary incentive for pooling. Only 8% of HOV drivers identified HOV lanes as a primary incentive if the lanes had been opened within the last 6 months.
- Cost savings was the second most often cited reason for pooling.
- HOV lanes caused 22% of the solo drivers and 57% of the Carpool drivers to change their behavior.
- Eleven percent of the respondents identifying themselves as primarily solo drivers changed their driving time because of the HOV lanes. Four percent of the solo drivers chose to carpool regularly or occasionally while 3% changed their route. The remaining 5% made other unspecified changes. (The percents add up to greater than 22% because multiple responses were allowed.)
- Less than half (43%) of the respondents identifying themselves as carpoolers were unaffected by the HOV lanes. About 35% had previously used another mode. About 17% changed

69 Billheimer, John W., Origin/Destination Surveys in Six Bay Area Corridors, for Caltrans District 04, by Systan Inc., Los Altos, CA, March 1995.

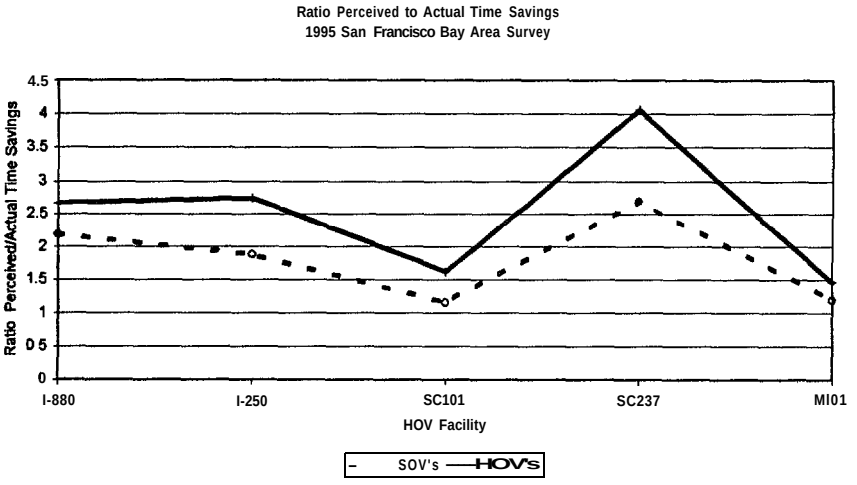
their driving time and 6% changed their route. The remaining 5% made other unspecified changes. (The percents add up to greater than 57% because multiple responses were allowed.) (See Figure D-10).

Figure D-10 Impact of HOV lanes on Carpoolers



- HOV drivers tend to perceive the benefits of HOV lanes much more optimistically than do SOV drivers. SOV drivers however also tend to over estimate the actual time savings of HOV lanes by a factor of two. HOV drivers tend to over estimate the time savings by a factor of almost three (see Figure D-l 1)

Figure D-l 1 Ratio of Perceived to Actual Time Savings of HOV Lanes



D.6.2 I-280 HOV Facility - Santa Clara County, California

An 11.2~mile section of I-280 from Magdalena Avenue in Cupertino to Leland Avenue in San Jose was widened from 6 lanes to 8 lanes in November/December 1990 (see Table D-27). The two additional lanes were designated as left-hand side, concurrent flow HOV lanes during the AM and PM peak periods. The northbound HOV lane is 10.7 miles (17.2 km) long. The southbound HOV lane is 11.2 miles (18.0 km) long. Buses, vanpools, motorcycles, and 2+ person carpools may use the HOV lanes during the peak periods. The HOV lanes are open to all vehicles during the rest of the day.

Data Collection

The Highway Operations Branch of Caltrans District 4 collected "before" data prior to the opening of the HOV lanes on I-280. The "after" data was collected after several months of operation in 199 1. The 'before-and-after" data contain vehicle counts by lane for HOV lane and general-purpose lane, person counts by lane for HOV lane and general-purpose lanes, violation vehicle counts on HOV lane, and travel speeds for HOV lane and general-purpose lanes. No specific dates are given for the before and after surveys.

Data reported includes:

- Speed profiles for peak hour for AM and PM both directions.
- Travel times for AM and PM Peak periods both directions.
- Vehicle occupancy for AM and PM peak period both directions.
- Vehicle counts for total of all lanes during peak period or lane by lane for peak hour.

The counts were taken at a midway point on the facility between Lawrence Expressway and Wolfe Road.

Data Reduction

Description: This data set shows the impacts of adding a concurrent flow, left-hand side HOV lane for 10.7 miles (17.2 km) in the northbound direction on a 6 lane freeway. The HOV lanes were opened to traffic on November 2 1, 1990 (northbound) and December 1, 1990 (southbound). Ramp metering with HOV bypasses was present before and after the addition of the HOV lane.

Travel Time Data: The maximum travel times for the mixed flow lanes were read directly from the peak period travel time profiles for the northbound direction, morning peak period. The means were obtained graphically from the profiles.

Volume Counts: Peak period volume counts by occupancy type and vehicle type were obtained directly from the tabulations in the report. The data was not broken down by lane type. Peak hour volumes by lane type (but not by occupancy type) were read from the bar graphs contained in the report.

The before/after study results are summarized in Table D-28.

Sources

1. Caltrans - District 4, Highway Operations Branch. Route 280 - Magdalena Avenue to Leland Avenue, HOVL Evaluation Report, November 199 1.

Table D-27. I-280 Santa Clara HOV Facility

Characteristics	I-208 HOV System
Begin and End	Magdalena Avenue to Leland Avenue
# of HOV lanes	1 lane in each direction
# of general purpose lanes	3 lanes in each direction
Length (mi.)	11.2 miles
Date Operational	November 1990 (NB), December 1990 (SB)
HOV Eligibility	2+
Hours of HOV Operation (weekdays only)	5:00 to 9:00 am, 3:00 to 7:00 pm
Type of facility	concurrent
Ramp Metering	6 HOV meter bypass lanes

Table D-28. I-280 HOV Lane Results

Action:
Construct 10.7 mile HOV lane[70]

	Peak Hour	Peak Period
HOV Lane Volume (After)	1840	
Change in Total Vehicles[71]	+15%	+3 1%
Change in Total Persons[72]	+22%	+40%
Average Vehicle Occ.[73]: Before: After:	 1.13 1.20	 1.11 1.19
Change in HOV Time[74]	Save 13 minutes	Save 9 minutes
Change in SOV Time[75]	Save 5 minutes	Save 6 minutes

70 Data is for morning peak period (7:00 AM to 9:00 AM), northbound direction. Report is unclear on dates of data collection.

71 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

72 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

73 Total persons divided by total vehicles. Includes buses and vans.

74 Mean time savings for HOV lane expressed as "Before" minus "After. Rounded to nearest whole minute.

75 Mean time savings for mixed flow lane drivers expressed as "before" minus "after.

D.6.3 US-101 (Lawrence to Guadalupe) HOV Facility - Santa Clara County, California

The section of US 101 between Lawrence Expressway and Guadalupe Parkway was widened from 6 lanes to 8 lanes in November 1986. The two added lanes were designated as HOV lanes located in the freeway median. The HOV lanes were opened in November 1986. The HOV lanes are restricted to buses, vanpools, and 2 or more persons during peak hours: 5-9 AM, and 3-7 PM (See Table D-29).

The HOV lanes consist of 2.83 mile concurrent flow HOV lane in the northbound direction, and a 3.18 mile concurrent flow lane in the southbound direction.

The peak flow directions are northbound in the morning and southbound in the afternoon.

Data Collection

The Highway Operations Branch of Caltrans District 4 collected "before" data prior to the opening of the HOV lanes on US-101. Two sets of "after" data were collected: One, in 1987 between Lawrence Expwy and Guadalupe Parkway, and the second set, in 1993 between Guadalupe Parkway and I-280/I-680/US101 interchange. The "first" "after" data set is reported here.

The first set of "after" data was collected in 1988 after a few months of operation. The "before-and-after" data contain vehicle counts by lane for HOV lane and general-purpose lane, person counts by lane for HOV lane and general-purpose lanes, violation vehicle counts on HOV lane, and travel speeds for HOV lane and general-purpose lanes. No specific dates are given for the before and after surveys.

The counts were taken at a point approximately midway between the endpoints of the project.

Data Reduction

Description: This data set shows the impacts of adding a concurrent flow, left-hand side HOV lane for 2.8 miles (4.5 km) in the northbound direction on a 6 lane freeway. The HOV lanes were opened to traffic on November 7, 1986 (northbound) and November 10, 1986 (southbound). Ramp metering with HOV bypasses was present before and after the addition of the HOV lane.

Travel Time Data: The maximum travel times for the mixed flow lanes were read directly from the peak period travel time profiles for the northbound direction, morning peak period. The means were obtained graphically from the profiles.

Volume Counts: Peak period volume counts by occupancy type and vehicle type were obtained directly from the tabulations in the report. This data was not broken down by lane type but total peak period volumes by lane type were obtainable from the bar graphs. Peak hour volumes by lane type (but not by occupancy type) were read from the bar graphs contained in the report.

The results are summarized in Table D-30.

Source

1. Caltrans - District 4, Highway Operations Branch, SCL-101 Commuter Lane -Lawrence Expressway to Guadalupe Parkway Preliminary Evaluation Report, June 1988.

Table D-29. US 101 Guadalupe to Lawrence HOV Facility

Characteristics	US 101 HOV System
Begin and End of Section	Lawrence Expwy to Guadalupe Parkway
# of HOV lanes	1 lane in each direction
# of general purpose lanes	3 lanes in each direction
Length (mi.)	2.83 (N-B), 3.18 (SB)
Date Operational	November 1986
HOV Eligibility	2+
Hours of HOV Operation (weekdays only)	5:00 to 9:00 am, 3:00 to 7:00 pm
Type of facility	concurrent
Ramp Metering	3 HOV bypass lanes

Table D-30. US 101 Guadalupe to Lawrence HOV Lane Results

Table 29 Before/After Results for US 101 HOV (Guadalupe-Lawrence), San Jose, Ca.		
Action: Construct 2.8 mile HOV lane[76]		
	Peak Hour	Peak Period
HOV Lane Volume (After)	710	1730
Change in Total Vehicles[77]	+6%	+7%
Change in Total Persons[78]	+12%	+11%
Average Vehicle Occ.[79]: Before: After:	 1.12 1.18	 1.13 1.17
Change in HOV Time[80]	Save 8 minutes	Save 6 minutes
Change in SOV Time[81]	Save 4 minutes	Save 3 minutes

76 Data is for morning peak period (6:00 AM to 9:00 AM), northbound direction. Report is unclear on dates of data collection.

77 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

78 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

79 Total persons divided by total vehicles. Includes buses and vans.

80 Mean time savings for HOV lane expressed as "Before" minus "After. Rounded to nearest whole minute.

81 Mean time savings for mixed flow lane drivers expressed as "before" minus "after.

D.6.4 U.S. 101 (Guadalupe to I-680) - Santa Clara County, California

The section of US-10 1 between Guadalupe Parkway and I-280/I-680/US 101 interchange was widened from 4/6 lanes to 8 lanes for its entire length. The effect was to add one lane in each direction to the six lane sections for the HOV lanes and to add two lanes (one HOV, one mixed flow) to the existing four lane sections of the freeway (see Table D-3 1).

The HOV lanes and the added mixed flow lane sections were opened to operation in February and April of 1993. The HOV lanes are restricted to buses, vanpools, and 2 or more persons during peak hours. This facility is a 5.8 miles of concurrent flow lanes for both directions.

This project was an HOV lane gap closure project. Prior to this widening project, HOV lane facilities on US-101 were separated into two facilities to the north and to the south of this section. This gap section consequently usually experienced congestion during the peak hours.

Data Collection

The Highway Operations Branch of Caltrans District 4 collected "before" data prior to the opening of the HOV lanes on US 10 1. Unfortunately, no dates are given for these studies. The "before-and-after" data contain vehicle counts by each lane for HOV lane and general-purpose lane, person counts by each lane for HOV lane and general-purpose lanes, violation vehicle counts on HOV lane, and travel speeds for HOV lane and general-purpose lanes.

Data Reduction

Description: This data set shows the impacts of adding a concurrent flow, left-hand side HOV lane for 6.0 miles (9.7 km) in the northbound direction on a 6 lane freeway. The last section of the HOV lanes was opened to traffic on April 5, 1993. Ramp metering with HOV bypasses was present before and after the addition of the HOV lane,

Travel Time Data: The maximum travel times for the mixed flow lanes were read directly from the peak period travel time profiles for the northbound direction, morning peak period. The means were obtained graphically from the profiles.

Volume Counts: Peak period volume counts by occupancy type and vehicle type were obtained directly from the tabulations in the report. This data was not broken down by lane type. Peak hour volumes by lane type (but not by occupancy type) were read from the bar graphs contained in the report. The peak period violation rate was 5% of the HOV lane volume.

The results are summarized in Table D-32.

Source

1. H. David Seriani, Caltrans - District 4, Highway Operations Branch, SCL-Route 10 1 HOVL Gap Closure (Route 280/680/101 Interchange to Guadalupe Parkway Preliminary HOVL Evaluation Report, December 1993.

Table D-31. US 101 HOV Lane, I-680 to Guadalupe

Characteristics	
# of HOV lanes	1 lane in each direction
# of general purpose lanes	3 lanes in each direction
Length (mi.)	11.2 miles
Date Operational	April 1993
HOV Eligibility	2+
Hours of HOV Operation (weekdays only)	5:00 to 9:00 am, 3:00 to 7:00 pm
Type of facility	concurrent
Ramp Metering	2 HOV bypass lanes

Table D-32. US 101 Results, I-680 to Guadalupe

Action: Construct 6.0 mile HOV lane[82]		
	Peak Hour	Peak Period
HOV Lane Volume (After)	1840	-
Change in Total Vehicles[83]	+21%	+22%
Change in Total Persons[84]	+28%	+34%
Average Vehicle Occ.[85]:		
Before:	1.30	1.16
After:	1.38	1.33
Change in HOV Time[86]	Save 12 minutes	Save 8 minutes
Change in SOV Time[87]	Save 5 minutes	Save 1 minutes

82 Data is for morning peak period (7:00 AM to 9:00 AM), northbound direction. Report is unclear on dates of data collection.

83 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

84 Total person8 in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

85 Total persons divided by total vehicles. Includes buses and vans.

86 Mean time savings for HOV lane expressed as "Before" minus "After. Rounded to nearest whole minute.

87 Mean time savings for mixed flow lane drivers expressed as "before" minus "after.

D.6.5 SR237 HOV Facility - Santa Clara County, California

This project is a pair of 6.0 mile long right-hand side, concurrent flow HOV lanes (one in each direction) that were added to the shoulders of a four lane (2-lanes in each direction) expressway. Signals are spaced one to two miles apart. Free-Flow speeds exceed 55 mph. No access is allowed to the expressway between the signalized intersections. The HOV lanes opened October 1984 (see Table D-33).

The peak direction of flow is westbound in the morning and eastbound in the afternoon. Congestion is severe in the peak directions at many of the signalized intersections.

Data Collection

The Highway Operations Branch of Caltrans District 4 collected "before" data prior to the opening of the HOV lanes on SR237. The "after" data was collected approximately six months after the start of operation. Unfortunately, no dates are given for these studies. AM and PM peak period vehicle and person volumes are reported. The vehicle counts are stratified by occupancy and vehicle type. The total peak period volumes are also stratified between the HOV lane and mixed flow lanes. Violation rates are reported for each peak period over 5 days. Travel time data is reported for five "before" floating car runs (made over a 10 month period) and four "after" floating car runs (made over a 3 month period).

Data Reduction

Description: This data set shows the impacts of adding a concurrent flow, right-hand side HOV lane for 5.9 miles (9.5 km) in the westbound direction on a 4 lane expressway with signals every one to two miles. This portion of SR-237 was not a freeway at the time of the HOV lane project. No ramp metering was present.

Travel Time Data: The maximum travel times for the mixed flow lanes were read directly from the peak period travel time profiles for the westbound direction, morning peak period. The means were obtained graphically from the profiles.

Volume Counts: Peak period volume counts by occupancy type and vehicle type were obtained directly from the tabulations in the report. This data was not broken down by lane type. Peak hour volumes by lane type (but not by occupancy type) were read from the bar graphs contained in the report. The violation rate was 9% of the HOV lane volume.

Table D-34 summarizes the results of the before/after study.

Source

1. Caltrans - District 4, Highway Operations Branch, SCL 237 Commuter Lane - Summary of Data Collected During the First Six Months of Operation, May 1985.

Table D-33. SR-237 Expressway HOV Lane

Characteristics	SR237 HOV System
Begin and End	I-880 to MagdaIena Avenue
# of HOV lanes	1 shoulder lane in each direction
# of general purpose lanes	2 lanes in each direction
Length (mi.)	6 miles
Date Operational	October 1984
HOV Eligibility	2+
Hours of HOV Operation (weekdays only)	5:00 to 9:00 am (WB), 3:00 to 7:00 pm (EB)
Type of facility	concurrent

The HOV lane is the rightmost lane. A portion of it runs on a permissive shoulder which reverts to regular shoulder use at off-peak hours.

Table D-34. SR-237 HOV Lane Results

Action:
Construct 5.9 mile HOV lane[88]

	Peak Hour	Peak Period
HOV Lane Volume (After)	957	-
Change in Total Vehicles[89]	-	+39%
Change in Total Person[90]	-	+45%
Average Vehicle Occ.[91]:		
Before:	-	1.20
After:	-	1.25
Change in HOV Time[92]	Save 6 minutes	Save 4 minutes
Change in SOV Time[93]	Save 4 minutes	Save 3 minutes

88 Data is for morning peak period (6:00 AM to 900 AM), westbound direction. Report is unclear on dates of data collection.

89 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

90 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

91 Total persons divided by total vehicles. Includes buses and vans.

92 Mean time savings for HOV lane expressed as "Before" minus "After. Rounded to nearest whole minute.

93 Mean tune savings for mixed flow lane drivers expressed as "before" minus "after.

D.6.6 US 101 Marin HOV Facility

The US 10 1 Marin HOV facility consists of two HOV lane sections on the US 10 1 freeway that are separated by about 3 miles. The northerly section extending from North San Pedro Road in San Rafael to Route 37 in Novato is about 6.1 miles (.8 km) long. The southerly section, extending from Richardson Boulevard in Saucelito to Sir Francis Drake Boulevard in Greenbrae (or Larkspur) is about 3.7 miles (5.9 km) long.

The US 101 freeway in Marin is unique in that there are literally no parallel arterials or freeways for traffic to divert to in this corridor. The nearest parallel road is State Highway One which winds along the Pacific Coast.

Project History

The project opened originally as bus lanes in the southerly, 3.7 mile long section of US 10 1. Three-plus HOV's were allowed to use the bus lanes on June 16, 1976. The northerly, 6.1 mile long, HOV lane section was opened in August 20, 1986 for 3+ HOVs Two-plus HOV's were allowed to use both northerly and southerly sections of the HOV lanes on October 1, 1988. Ramp metering was not and is not present in this corridor.

Data Collection

Action "A". Conversion from Bus to 3+ HOV: The Before/After data for this action was obtained from Caltrans District 4 offices and Systan files. The before study was conducted in March 1976, about 3 months before the conversion. The after study was conducted in March 1977, about 9 months after the conversion. Data is available only for the peak hour. The before/after data apply only to the southerly, 3.7 mile long HOV lane section of US 101 in Marin County.

Action "B". Conversion from 3+ HOV to 2+ HOV: The Before/After data for this action was obtained from a before/after study by Caltrans[94]. The before data was collected in September 13-28, 1988. The after data was collected in November 1988, December 1988, February 1989, and March 1989. Data is available for the AM and PM peak hours and peak periods. The data reported in this chapter for this action is only for the southerly, 3.7 mile long, section of the HOV lanes on US 101. Only the AM peak period data is reported here.

Data Reduction

Description: The data set shows the impacts of two actions: converting a bus lane to 3+HOV's, and converting the same HOV lanes from 3+ to 2+.

Travel Time Data: The data shows a reduction in travel times for HOV's and no change in travel times for the mixed flow lanes for the conversion from bus lanes to 3+ HOV's The conversion from 3+ to 2+ HOV resulted in a slight increase in travel times for 3+ HOV's and a more significant reduction in travel time for SOV's and 2 person carpools.

Volume Counts:

Action "A", Conversion from bus to 3+ HOV: Vehicle volumes by occupancy type were estimated for SOV and 2 person car-pools based on the reported passenger volumes. The split in vehicle volumes between 3 person HOV's and 4+ HOV's was estimated based upon the reported passenger volumes for 3+ HOVs. Truck and motorcycle volumes were not available. Bus volumes for the mixed flow lanes were not available.

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94 W R Shoemaker, Marin 10 1,2+ HOV Lane Occupancy Trial Period, October 1988 - March 1989, Operational Evaluation, Caltrans District 4, Highway Operations Branch, Oakland, CA, July 1989.

Action "B", Conversion from 3+ to 2+ HOV: All vehicle data was available by occupancy type. No conversion or splitting of the data was required.

D.7 SANTA CLARA COUNTY, CALIFORNIA

Santa Clara County has been operating HOV lanes, or "commuter-lanes" on signalized arterial streets since 1982. They are currently operating HOV facilities on the San Tomas Expressway and the Montague Expressway and HOV queue bypass lanes on the newly opened Central Expressway. The HOV lane facilities on the San Tomas and Montague Expressways are implemented on the right most lane. The eligibility of all HOV facilities is 2 or more persons per vehicle. These HOV lanes are in operation only during the peak hours, otherwise they carry mixed flow traffic Table D-35 illustrates some general information for HOV lane facilities under Santa Clara County's jurisdiction. Santa Clara County is currently constructing an additional HOV lane on the Lawrence Expressway. It is anticipated that this new HOV facility will be open in early 1997.

The arterial HOV facilities in Santa Clara County are part of the Santa Clara County Commuter Lane network. The County's Transportation 2000 Plan includes a 140-mile network of commuter lanes on freeways and expressways. About 17 lane miles of concurrent flow arterial HOV lanes are operational during the peak period only.

The Traffic and Electrical Operations is responsible for the data collection for HOV facilities. In general, the data is prepared on a semi-annual base by observers. The data collection are conducted during peak hours in the spring and fall when school is in session, Both mechanical and manual counts are used for collecting HOV lane data. The loop detectors mechanically counts 24-hour traffic volumes. Manual counts are made for the vehicle occupancy and percentage of HOV lane usage. The data contain 24-hour through traffic counts by direction only, peak hour vehicle counts for HOV and general-purpose lanes, percentage of HOV lane usage (HOV lane vs. general-purpose lanes), vehicle occupancy for HOV lane and general-purpose lanes. and average travel time and travel speeds. The HOV facility data is available in both hardcopy and IBM-based Lotus files. Dam older than two years old is not retained.

The annual "Commuter Lane Report" includes data for the San Tomas Expressway and Montague Expressway. The data for HOV queue bypass lanes on Central Expressway is not yet available since the bypass opened in 1994.

Adequate before and after data was found for the San Tomas Expressway commuter lanes in the "Commuter Lane Performance Evaluation" prepared by Systan in 1989. The available "before" data for the other HOV projects was less satisfactory and could not be included in the methodology database.

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D.7.1 San Tomas Expressway - Santa Clara County, California

The San Tomas Expressway is a 6 lane expressway with shoulder and curb lane HOV lanes. The HOV lanes are right-hand side, concurrent flow lanes extending for 6.5 miles. The northbound lane is open 6 AM to 9 AM weekdays. The southbound lane is open 3 PM to 7 PM weekdays. The HOV lanes are restricted to 2+ occupant vehicles plus motorcycles.

The first 4.9 mile (7.9 km) stage of the project opened November 22. 1982. The second 1.6 mile (2.6 km) stage of the project opened on April 1984. The first stage of this project was selected for the methodology development database. The lack of 1984 data precluded the incorporation of the second stage of this project in the methodology database.

Table D-35. Santa Clara County Expressway HOV Facilities

Characteristics	Santa Clara County		
Corridor	**San Tomas Expwy (commuter lane)**	**Montague Expwy (commuter lane)**	**Central Expressway (ramp queue bypass)**
Begin and End/Ramp Locations	**Walsh to Budd**	**US101 to I-680**	**Bowers, Scott**
# of Directional HOV lanes	**2**	**2**	**1 on-ramp**
Length (mi.)	**6.5**	**4.5**	**N/A**
Date Operational	**82/84**	**83/90**	**94**
HOV Eligibility	**2+**	**2+**	**2+**
Hours of HOV Operation (weekdays only)	6-9am NB 3-7pm SB	6-9am WB 3 -7pm EB	
Type of facility	striped concurrent (rightmost lane)	striped concurrent (rightmost lane)	striped concurrent on-ramp lanes

All HOV lanes are on the left side unless otherwise noted.

Source: County of Santa Clara, Roads & Airports Department, 1993 Commuter Lane Report, 1993.

Data Collection

Vehicle counts and passenger counts are available for the peak direction of the AM and PM peak periods on the San Tomas Expressway for the years 1982, 1983, 1985, 1986, 1987, and 1988. Violation rates are available for 1985, 1986, 1987, and 1988. Time savings data is available for 1983, 1985, 1986, 1987, and **1988.**

The vehicle counts are not stratified by occupancy type or vehicle type, but are stratified by lane type (HOV lane vs. other lanes).

Data Reduction

Description: This data set shows the impacts of adding a concurrent flow, right-hand side HOV lane for 4.9 miles (7.9 km) in the northbound direction on a 6 lane signalized expressway.

Travel Time Data: The maximum and mean travel time savings for the HOV lanes were read directly from the project data summary tabulations. The HOV time savings were converted to actual travel times assuming that the average speed in the HOV lanes was 45 mph (72 kph). The mixed flow lane travel times for the before condition were not reported, so they were assumed to be the same as the after travel times.

Volume Counts: Peak period volume counts by HOV lane and the other lanes were obtained directly from the tabulations in the report. This data was not broken down by vehicle type or occupancy type. Peak hour volumes were not reported. The AM peak period violation rate was 5% of the HOV lane volume in 1985.

Table D-36 summarizes the results of the before/after study.

Source

Systan Inc., Santa Clara County Commuter Lane Performance Evaluation, Final Report, Santa Clara County Transportation Agency, San Jose, California, March 1, 1989.

Table D-36. San Tomas Expressway Results

Action:
Construct 4.9 mile HOV lane[95]

	Peak Hour	Peak Period
HOV Lane Volume (After)	-	1049
Change in Total Vehicles[96]	-	+13%
Change in Total Persons[97]	-	+18%
Average Vehicle Occ.[98]:		
Before:	-	1.10
After:	-	1.15
Change in HOV Time[99]	-	Save 2 minutes
Change in SOV Time[100]	-	Save 0 minutes (est.)

95 Data is for morning peak period (6:00 AM to 9:00 AM), northbound direction. Report is unclear on dates of data collection.

96 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

97 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

98 Total persons divided by total vehicles. Includes buses and vans.

99 Mean time savings for HOV lane expressed as "Before" minus "After. Rounded to nearest whole minute.

100 No data. Assumed to be zero.

D.8 SNOHOMISH AND KING COUNTIES, WASHINGTON

The Puget Sound region is one of the few areas in the U.S. to have implemented a HOV lane on an arterial street since the 1980's. Snohomish and King Counties are part of the Puget Sound region. Long range plans in the region would extend the HOV network to all freeways and many of the major arterial streets. The existing HOV facilities in the area are listed below:

1. Downtown Seattle - Right parking lanes on Second and Forth Avenues, one-way streets, are use for buses only during AM and PM peak periods. Both of HOV bus lanes are about one mile in length. Another facility located on Fifth Avenue is a contra-flow lane operating in the PM peak period.
2. SR99 - Outside northbound right lane between the Seattle city limits at N. 145th Street and N. 120th Street is required 3 or more persons, and right turning vehicle to be eligible for the facility. This HOV facility is about 1.5 mile in length and operates for 24-hour a day.
3. University of Washington - Eastbound on NE Pacific Street outside lane is required 2 or more to be eligible for the facility.
4. SR522 - Northbound parking strip between NE 130th Street and city limits at NE 145th Street, about 1 mile in length, is reserved for 3 or more and buses during the PM peak period. Southbound shoulder between Kenmore and the Seattle city limits at NE 145th Street is reserved for buses only for 24-hour a day.
5. Airport Road/128th Street - Northbound outside lane between 4th Avenue and SR99, 1 mile in length, is operating in the AM peak hours. Southbound outside lane between SR526 and 4th Avenue, 3.3 miles in length, is operating in the PM peak hours. Both of these directional HOV lanes were implemented in January 1993 in Snohomish County, and required 2 or more to be eligible for the facilities.

The University of Washington has done a great deal of work on arterial HOV facilities. A number of arterial studies have been conducted or are underway in the Puget Sound region.

A "before and after" study has been published for the Snohomish County Public Works on the Airport Road HOV Program. Public Works collected data prior to construction and 3-months, 6-months, and 1 year following construction and continues to collect the data, including vehicle volumes, occupancy, and speeds.

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D.8.1 Airport Rd./128th St. SW, Seattle, Washington

The Airport Road/l28th Street SW corridor consists of a 3.4 mile (5.5 km) long, four lane wide, divided, signalized arterial street. A 3.3 mile (5.3 km) long eastbound HOV lane and a 1 mile (1.6 km) shoulder HOV lane were added in January 1993. The lanes occupy the curb lane. Approximately 11 signals are in place along the length of this corridor. Two plus person vehicles are eligible to use the HOV lanes during each peak hour.

Data Collection

Vehicle counts and passenger counts are available for the eastbound direction during the PM peak hour for "before", 3 months after, 6 months after, and one year after opening of the eastbound HOV lane. Violation rates are not reported. Average HOV lane and mixed flow lane vehicle speeds are reported for the same periods.

The vehicle counts are not stratified by occupancy type, vehicle type, or lane type (HOV lane vs. other lanes).

Data Reduction

Description: This data set shows the impacts of adding a concurrent flow, right-hand side HOV lane for 3.3 miles (5.3 km) in the eastbound direction on a 4 lane, divided, signalized arterial.

Travel Time Data: The mean peak hour travel times for the HOV lanes and the mixed flow lanes were computed based on the reported mean speeds and the length of the HOV lane. Maximum travel times were not reported and were consequently assumed to be the same as the mean peak hour times.

Volume Counts: Peak hour vehicle and person volume counts were obtained from the bar graphs in the report. This data was not broken down by vehicle type, occupancy type, or lane type. Peak period volumes were not reported. Violation rates were not reported.

The before/after study results are summarized in Table D-37.

Source

Owen Carter, James Bloodgood, "Snohomish County Public Works Airport Road HOV Program", Compendium of Technical Papers, Institute of Transportation Engineers, 47th District 6 Annual Meeting, Portland, Oregon, July, 1994.

Table D-37. Airport Road HOV Lanes Results

Action: Construct 3.3 mile arterial HOV lane[101]		
	Peak Hour	Peak Period
HOV Lane Volume (After)		
'Change in Total Vehicles[102]	-9%	-
Change in Total Persons[103]	+8%	-
Average Vehicle Occ. [104]: Before: After:	 1.27 1.50	 - -
Change in HOV Time[105]	Save 1 minute	-
Change in SOV Time [106]	Save 0 minutes	-

101 Data is for evening peak hour only, eastbound direction. After data is for one year after opening.

102 Total vehicles (sum of HOV lane plus mixed flow lanes) in peak direction, expressed as "After" minus "before", divided by "before".

103 Total persons in peak direction in all vehicles, in all lanes expressed as "After" minus "before", divided by "before".

104 Total persons divided by total vehicles. Includes buses and vans.

105 Mean time savings for HOV lane expressed as "Before" minus "After. Rounded to nearest whole minute.

106 No data. Assumed to be zero.

D.9 VIRGINIA DEPARTMENT OF TRANSPORTATION

The Virginia Department of Transportation has been operating HOV lane since 1969 and currently operates 5 HOV facilities in the Northern Virginia area. Types of HOV facilities range from barrier-separated reversible lanes to barrier-separated two-way lanes to concurrent freeway lanes. Except for a section of the I-66 corridor, the HOV lanes require 3 or more persons per vehicle to be eligible. Hours of operation vary by route. Table D-38 shows general information on HOV facilities for the northern Virginia area.

The opening of the Shirley Highway to buses in 1969 was the first use of an HOV facility on a freeway in the U.S. Since opening, the occupancy requirement and operating hours have changed a number of times. Several studies have been conducted on the Shirley Highway since its inception as an "express-bus-on-freeway" demonstration. This data is currently being processed by the team and is not reported in this . The Virginia DOT has plans to conduct a "before-and-after" study on the conversion of the I-66 HOV project from 39 to 2+ in the near future.

The Virginia Vanpool Association (VVPA) plays an active role in the promotion and support of Vanpools in the northern Virginia/Washington. D.C. metropolitan arca. They have conducted several surveys of vanpool drivers and riders.[107]

The Metropolitan Washington Council of Governments has been conducting Metro core cordon counts since 1974. These counts were initially annual studies. They have been conducted every two to three years since 1981. The cordon counts include vehicle and passenger counts for the morning and evening peak periods of both the mixed flow and HOV lanes on the Shirley Highway and I-66. The monitoring data does not include travel time or speed measurements.

The Metropolitan Washington Council of Governments has also conducted surveys of Vanpool drivers and carpoolers including a "1987 Survey and Evaluation of Ride Finders Ridesharing Network" and a 1989 survey of Vanpool drivers which found their main concern to be HOV lanes over parking, insurance, costs, and riders.

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D.9.1 Shirley Highway (I-395) - Washington, D.C./Northern Virginia

The first use of a HOV facility on a freeway in the United States was the five miles of bus-only lanes on the Shirley Highway which opened in 1969 The facility provides access to Washington, D.C. from the southwest. The HOV facility is a barrier-separated, reversible, two-lane facility located in the median of the freeway (see Table D-39 for project history).

Park-and-ride lots and direct access ramps are located along the corridor. Metrorail Yellow Line opened in 1983

Several studies were conducted when the Shirley Highway first opened to buses in 1969.

As part of the Express-Bus-on-Freeway Demonstration Project. several reports were written about the Shirley Highway. The demonstration project was sponsored by the U.S. DOT and comprised of three

[107] Lew W. Pratsch. "Vanpools an HOV lanes: Major Keys to Reduce Traffic Congestion," 4th National Conference on High Occupancy Vehicle Facilities, April 11, 1990.

elements - 11-miles of HOV lanes, new buses in express service, and park-and-ride lots. Data collected included vehicle volumes and person trip counts at 8 stations along a screenline to cover changes in the corridor and not just the Shirley Highway. Bus data included adherence to schedules, number of passengers, costs, and travel times. Actual and perceived travel times were collected for buses and autos. Surveys of auto and bus commuters and park-and-ride users were conducted.

For the Shirley Highway Operations Study conducted in 1976, vehicle volumes were collected manually and by machine at approximately 50 locations to supplement existing counts. Speeds and travel times were collected for the mainline study section.

Data Collection

The majority of published before/after studies for the Shirley Highway HOV Facility were made when the facility operated as an exclusive bus facility.

Vehicle counts and passenger counts for the HOV lanes are available by vehicle type for the AM peak period for 1979, 1980, 1981, 1983, 1985, 1987, 1990, and 1993. This data is available in the most recent Metro Core Cordon Report published by the Metropolitan Washington Council of Governments. Similar historical data is available for the mixed flow lanes, but must be obtained from each year's report.

Total vehicle volumes during the morning peak period (6-9 AM) in the HOV lanes increased from 4608 to 6593 between 1987 and 1990. Passenger volumes increased from 30,717 to 37,610. The HOV lanes were converted from 4+ HOV to 3+ HOV in January 1989.

Unfortunately, none of the cordon reports provide travel time data collected simultaneously with the volume counts.

Sources

1. Gerald K. Miller and Keith M. Goodman. The Shirley Highway Express-Bus-on-Freeway Demonstration Project / First Year Results, Interim Report 2, UMTA, November 1972.
2. James T. Mc Queen, Richard F. Yates, and Gerald K. Miller. The Shirley Highway Express-Bus-on-Freeway Demonstration Project / Second Year Results, Interim Report 4, UMTA, November 1973.
3. JHK Associates. Shirley Highway Operations Study, August 1976.
4. Jon Williams, 1993 Metro Core Cordon Count of Vehicles and Passenger Volumes, Metropolitan Washington Council of Governments, Washington D.C., May 1994.

Table D-38. Northern Virginia HOV Facilities

Characteristics	Northern Virginia DOT			
Corridor	I-395 Shirley	I-66	I-66	I-95 (interim)
Begin and End	Capitol Beltway to Potomac River	Capitol Beltway to Potomac River	Outside Beltway	
# of Directional HOV lanes	2	2 to 3	2	2
Length (mi.)	11	9.6	7	5
Date Operational	69/75	82		
HOV Eligibility	3+	3+	2+	3+
Hours of HOV Operation (weekdays only)	6-9am NB 3:30-6pm SB	6:30-9am EB 4-6:30pm WB	N/A	6-9am 3:30-6pm
Type of facility	barrier separated reversible lane	barrier separated two-way	striped concurrent each dir.	striped concurrent each dir.
Ramp Metering	Yes	Yes	Yes	

Sources:

Tumbull, Katherine. An Assessment of High-Occupancy Vehicle Facilities in North America: Executive Report, Texas Transportation Institute, August 1992, Table 1. General Characteristics of Operating HOV Facilities.

Fuhs, Charles. Inventory of Current and Proposed High-Occupancy Vehicle Projects in the U.S. and Canada, January 1995.

Table D-39. Shirley Highway HOV Facility History

Characteristic	Shirley Highway HOV System			
Corridor				Springfield I/C to 14th St. Bridge
# of HOV lanes	2			
# of general purpose lanes	3 in each direction			
Length	5 miles			11 miles
Date Operational	1969	Dec 1973	Jan 1989	July 1991
HOV Eligibility	buses only	4 +	3 +	2 +
Hours of HOV Operation	11:00 pm to 11:00 am inbound 1:00 pm to 8:00 pm outbound		6:00 am to 9:00 am inbound 3:30 pm to 6:00 pm outbound	
Type of facility	barrier-separated, reversible			
Ramp Metering				
Park-and-ride facilities	yes			
Other support facilities				
Bus Service		New express buses		

D.10 NEW JERSEY DEPARTMENT OF TRANSPORTATION

The New Jersey State Department of Transportation began operating its first HOV lane facility in March 1994. This new HOV lane facility is located on the I-80 corridor in Morris County and provides a concurrent lane in the eastbound and westbound directions. Two or more persons per vehicle are required to be eligible for the HOV lanes, which only operate during peak hours in the peak direction. Table D-40 provides a summary of the facility characteristics of the I-80 HOV lanes. This spring the New Jersey DOT will begin construction of another HOV lane facility on I-287 corridor and a queue bypass within the I-80/I-287 interchange.

The Bureau of Transportation Data Development (BTDD) is maintaining the data collection through the state. Most of data collection are contracted out with consultants. The pre-HOV data ("before" data) on the I-80 corridor is available which contains vehicle counts in 15-minute interval by types of vehicle, vehicle occupancy, and average travel speed.

A before-and-after report for the newly implemented HOV facility on I-80 is not available at this time, but is expected to be available for distribution soon.

Although a user survey for the HOV facility has not been conducted in I-80 corridor, the New Jersey DOT is planning on conducting a HOV lane user survey in the future.

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D.10.1 I-80 HOV Facility - Morris County, New Jersey

Initially, in 1991. the section of I-80 was under construction to provide an additional general purpose lane in both eastbound and westbound. At the meantime, the feasibility study of providing HOV facility along I-80 began. In 1992, the committee who reviewed the feasibility study concluded that HOV lanes could be operated on I-80. The HOV lanes extend from Route 15 to Beverwcy Road of the east, and are approximately 10.5 miles. The section on I-80 within the limits of the HOV lanes consists of 4 lanes (HOV lanes located in the median) in each direction, with an exception of the eastern portion. The HOV facility was opened to operation in March 1994, and was restricted for buses, Vanpools, and 2 or more persons during peak periods. It should be noted that existing 6 park-and-ride lots are located close to the western limits of HOV lanes where the commuter trip origins are. Table D-4 1 summarizes the HOV facility information for I-80 corridor.

As mentioned in the agency profile. the Bureau of Transportation Data Development (BTDD) is maintaining HOV lanes' data. The data collection effort was conducted by several consultants. The "before" data of I-80 corridor are available in 1989, 1991, and 1994. The "after" data was collected after the opening of operation in 1994.

The "before-and-after" data consists of vehicle counts by each lane for HOV lane and general-purpose lane, person counts by each lane for HOV lane and general-purpose lanes, violation vehicle counts on HOV lane, and travel speeds for HOV lane and general-purpose lanes. Prior to the HOV lane operations, a phone survey of motorists and executive interviews were performed to obtain attitudinal data for I-80 HOV lane facility. Although the "after" data has been collected, it will not be released until March 1995. Table 41 shows the "before" data and comparisons for I-80 HOV lane facility.

References:

1. Barbara L. Fischer. Lane Conversion Strategy for the I-80 High-Occupancy Vehicle Lanes in New Jersey, June 1994.

2. State of New Jersey, Bureau of Transportation Data Development. I-80 HOV Lane, Data Collection/Monitoring Program, December 1993.
3. New Jersey Department of Transportation - Office of Region II Design. I-80 HOV Lane Evaluation Plan - Revised Draft, March 1994.
4. Parsons Brinckerhoff Quade & Douglas, Inc., and Pacific Rim Resources, Route I-80 High Occupancy Vehicle Lane Feasibility Study, January, 1992.

Table D-40. I-80 New Jersey HOV Lanes

Characteristics	New Jersey DOT
Corridor	**I-80 Morris County**
Begin and End	**Mt. Home to Beverwyck**
# of Directional HOV lanes	**2**
Length (mi.)	**10.5**
Date Operational	**94**
HOV Eligibility	**2+**
Hours of HOV Operation (weekdays only)	**6-9am EB** 3-7pm WB
Type of facility	striped concurrent each dir.
Parallel roadway facilities	Rte 46 & Rte 10

All HOV lanes are on the left side unless otherwise noted.

Table D41. I-80 New Jersey HOV Lane Results

Date	# of Lanes		AM Peak Hour - Peak Direction (Eastbound) Counts						Occupancy (pers./veh.)		Travel Time 1 (min.)	
	HOV Lane	non-HOV	Bus		HOV Lane		non-HOV Lanes		HOV Lane	non-HOV	HOV Lane	non-HOV
			veh.	pers.	veh.	pers.	veh.	pers.				
1993	n.a.	3			n.a.	n.a.	4,680	5,124	**n.a.**	**1.1**	n.a.	n.a.
1994	1	3			n.a.	n.a.	n.a.	n.a.	**n.a.**	**n.a.**	n.a.	n.a.

1 Travel time not available. Average travel speed is 21.99 mph for eastbound direction during AM peak.

2 After data not yet available at time of printing. A "before-and-after" report is anticipated to be released in March 1995.